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Preventive Measures in Periodontology —*Aiguier*
Preparation of Ridges—*Molt*
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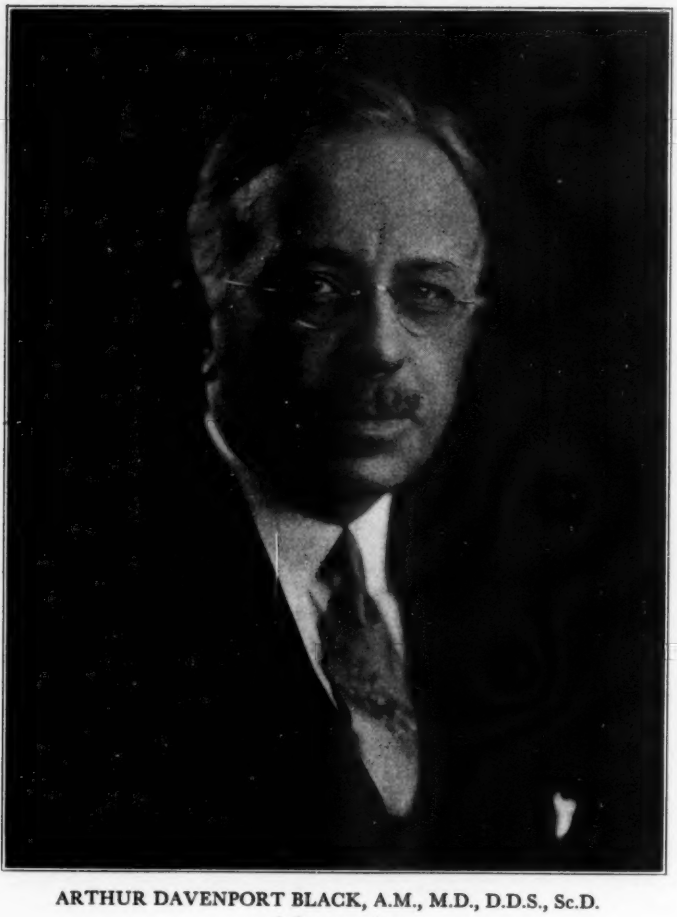

ARTHUR DAVENPORT BLACK, A.M., M.D., D.D.S., Sc.D.
(1870-1937)

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THE JOURNAL *of the*
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AN ANALYSIS OF ART FACTORS IN FULL DENTURE CONSTRUCTION

By VICTOR H. SEARS, D.D.S., New York City

TO some persons, art is a vague and mysterious thing, the preception and production of which depends entirely on the spark or flame of genius in the artist's soul. This belief misses the point that all of us have some artistic ability awaiting development. If art is the production of significant form, every normal child is an artist. Our attempts are quite naturally crude in the beginning, but thought, practice and systematic attack can make better artists of us all. In his narrow field of art, the dentist should hold the dual aim of making his dental restorations appear both true to esthetics and true to nature.

There is scarcely any field of endeavor —not even art—which does not lend itself to analysis. We can analyze the art factors of full denture construction under three headings: A, face; B, teeth, and C, gums.

THE FACE

It is logical to begin the study of esthetic problems of the patient's face by determining the desired degree of jaw separation, for when the opposing jaws are fixed much too far apart or much too close together, the attainment of pleasing and natural effects becomes difficult if not impossible. Human faces differ considerably in their proportions. The lower half of each face has a length determined by heredity and physical forces, not by the Greek proportion nor by a mean average. The significance of this fact from the artistic standpoint is that we are not bound to a definite degree of jaw separation: within the range of several millimeters, a satisfactory esthetic effect remains attainable.

It is well that this range is permissible, because, aside from esthetic considerations, other factors must be considered. Perhaps the most compelling requirement in the matter of jaw separation is the mechanical ideal of parallelism of the opposing ridges. Because this point is a mechanical one, it will not be considered here except to say that far from being a conflicting requirement, parallelism of opposing alveolar ridges in the bicuspid and first molar regions usually determines

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for us a satisfactory degree of jaw separation from the esthetic standpoint. This is most fortunate because it obviates the necessity for compromise. In those instances wherein the mechanical and esthetic requirements cannot be met with the same degree of jaw separation, the worker's judgment must be exercised to determine whether to favor the mechanical or the esthetic standard. When compromise is necessary, it will be found usually that mechanical considerations require greater closure, whereas esthetic considerations require greater opening. An appreciation of this fact will aid us in obtaining the most satisfactory compromise.

The chief reason that considerations of appearance require increasing the degree of jaw separation is that closure of the mandible with its consequent collapse of the lower part of the face is associated with advanced years. Excessive closure increases the apparent age of the face.

Several age characteristics accompany the closing of the jaw relation. Wrinkles about the nose and mouth deepen; the lips are squeezed as the chin is allowed to approach the nose. This closing action raises the level of the mouth without

TABLE 1.—RELATION OF WIDTH OF ANTERIOR TEETH TO WIDTH OF FACE*

	Upper		
Facial Width Mm.	136	148	160
Six anterior teeth, ÷ 3.3	41.2	44.6	48.5
Central incisor, ÷ 18	7.5	8.2	8.9
Lateral incisor, ÷ 22	6.2	6.3	7.3
Cuspid, ÷ 19	7.1	7.8	8.4
	Lower		
Six anterior teeth, ÷ 4.2	32.4	35.4	38.0
Central incisor, ÷ 29	4.7	5.0	5.5
Lateral incisor, ÷ 26	5.1	5.7	6.1
Cuspid, ÷ 21	6.5	7.0	7.6

*Appropriate widths of teeth for any width of face can be found by dividing the patient's facial width by the numbers indicated in the left hand column. As indicated in the second column from the left, a face measuring 136 mm. in width at the cheek bones would be appropriately fitted with upper incisors and cuspids whose combined widths would total 41.2 mm., whose upper central incisor in the average case would measure 7.5 mm. and so on down the column for the widths of the other teeth. Similarly, an appropriate width for the upper six anterior teeth in a face 148 mm. wide would be 44.6 mm. and so on down the third column. Tooth measurements for a face 160 mm. wide are suggested in the fourth column.

similarly raising the cheeks. The upper lip is thus pushed up so that the cheeks tend to fold over it and the lines from the base of the nose become deeper. Excessive closure pushes the mouth upward in the face, especially in the center portion, so that the upper lip is caused to bulge out and the corners of the mouth appear to have dropped.

This upward pressure on the upper lip raises the base of the nose without raising its tip, so that the nose becomes more hooked. The base of the nose widens as these other changes occur. The raising of the chin causes wrinkles to form at the corners of the mouth, and because the tissues of the cheeks are not carried upward by the mandible as the chin is raised, the cheeks hang comparatively low and form so-called "chops" or "jowls."

All of these changes of advancing age are departures from the esthetic ideal and should be reversed by increasing the degree of jaw separation, without, however, deviating too far from the mechanical ideal.

Just as the mechanical and esthetic requirements may conflict more or less in the matter of jaw separation, they sometimes conflict in the matter of width of the dental arches. Mechanical considerations require narrowing of the dental arches, while esthetics may require us to make them wide, especially in the bicuspid region. Fortunately, in this instance, it is possible for us to escape the dilemma with suitably designed tooth forms whose chewing surfaces are placed far enough lingually and whose buccal surfaces are carried far enough buccally. The labial and buccal tooth surfaces, together with the labial and buccal surfaces of the denture base, should be used to build out the face. The combination of jaw separation, placement of the teeth and bolstering of the lips and cheeks with the denture base can be used to great advantage in developing a pleasing appearance.

THE TEETH

The next problem of the prosthetist is that of the teeth, their selection, alteration and arrangement. A study of the teeth themselves suggests the following divisions for consideration: width, height, form, color, translucency and arrangement. An understanding of these six factors will aid us in achieving pleasing and natural effects.

Width.—The width of the assemblage of teeth as related to the width of the patient's face is of prime importance and it might well be considered before directing attention to the widths of the individual teeth, because these widths may be altered considerably without affecting the width of the assemblage.

The combined widths of the upper in-

TABLE 2.—CHANGES IN WIDTH OF INDIVIDUAL TEETH TO ALTER GENERAL COMPOSITION*

For 148 Mm. Facial Width			
Upper	Average	Delicate	Rugged
Six anterior teeth	44.6	44.6	44.6
Central incisor	8.2	8.5	8.0
Lateral incisor	6.3	6.0	7.0
Cuspid	7.8	7.8	7.3

*Taking the average width of the combined upper six anterior teeth as 44.6 mm. from Table 1, Table 2 indicates the character of changes in the widths of the individual teeth which may be made in order to alter the general impression of the composition. It will be seen that the greatest degree of alteration is allowable with the lateral incisor.

cisors and cuspids in pleasing natural dentures will be found to measure slightly less than one-third of the greatest facial width at the cheek bones. This ratio in middle life is fairly constant when the teeth are in proximal contact and not lapped. The combined widths of these teeth will be less if they are spaced and greater if they are lapped. The width of the mouth opening does not seem to be a factor in controlling the width of the natural tooth assemblage, but, in some instances, it might be wise to select slightly narrower artificial teeth for narrow mouths.

Perhaps the most practical means of arriving at suitable widths for all of the teeth is a table based on an analysis of cases chosen for their harmonious appearance. Table 1 gives the relation of each of the twelve anterior teeth to the width of the face, as well as the widths of the upper and lower sets of six.

Teeth chosen according to Table 1 will present suitable widths, but certain deviations are indicated in order to produce certain effects, especially in the comparative widths of the upper central and lateral incisors. Table 2 indicates how effects may be obtained by altering the comparative widths of the individual teeth while maintaining a fixed width for the combined six anterior ones.

One may not presume to say that any single formula will give the one allowable combination of widths or other dimensions, but some such formula as is embodied in Table 2 based on observation of pleasing natural teeth offers a helpful starting point. For example, if rugged strength is to be indicated, the lateral incisors may be made wider, this width being gained by making the central incisors narrower. Conversely, if the composition is to fit into a delicately molded face, the lateral incisors may be made narrower and the central incisors wider. Other modifications will be suggested presently in a discussion of the esthetic norm.

Height.—The height of the labial surface also controls the size of a tooth. As in the case of tooth width, so also the tooth height is modified by several factors. Because there is a fairly constant ratio between the widths of the combined anterior teeth and the width of the face, some have had the theory that such a ratio exists between face-height and tooth-height. However, there are so many more important controlling factors that the face-tooth ratio has little significance in the matter of height.

Granting that the artificial gums are to be made of a pink translucent material which can be made to simulate the natural gums in appearance, and the tooth height is to be computed as extending from the incisal edge to the gum line, the following considerations should be weighed: 1, position of the incisal edges; 2, high lip line of the upper denture and low lip line of the lower denture; 3, facial length; 4, degree of wear indicated according to the age of the patient, and 5, the width-height proportion. Let us consider these more closely.

1. *Position of Incisal Edges.*—Perhaps, for the average case, the incisal edges of the upper teeth can be safely set at the height of the lip line when the face is in repose but deviations are indicated. When such deviations are made, lowering the upper incisal edge calls for the selection of upper teeth having greater length, and vice versa. The same principle holds true with the lower teeth: raising the incisal edge lengthens the required vertical dimension of the teeth, whereas lowering shortens it. Excessive mobility of the lips during speech calls for higher upper incisal edges or more depressed lower incisal edges, or both.

2. *High and Low Lip Lines.*—In a similar way, increased distance between the rest lip line and the high lip line calls for longer upper teeth, just as increased distance between the rest lip line and the low lip line calls for longer lower teeth. The high lip line is determined ordinarily

by the patient's smile, and the low lip line by the drop of the lower lip in speech; but sometimes when the lips are exceptionally mobile in speaking, both the high and the low lip lines are located while the patient speaks.

3. *Facial Length.*—If the face is exceptionally long or, more accurately, if its lower half is exceptionally long, somewhat longer teeth may be selected than would be chosen in the absence of this condition.

4. *Degree of Wear.*—As the continual use of teeth for chewing causes them to be worn down progressively, short teeth connote advanced age. Thus, although fairly long teeth in an old face tend to make the face appear younger, it is not practical to go far toward rejuvenation by this means because unworn teeth in old faces present an incongruity which defeats our efforts toward pleasing effects.

5. *Width-Height Proportion.*—When all of the above-mentioned modifiers have been weighed for their influence on our selection, there remains one other consideration which is necessary to an esthetic effect: determination of a pleasing ratio of width to height. Teeth which are either too long or too short in proportion to their width do not appear pleasing.

It should be clear that the length of the labial surfaces cannot be determined by any single consideration. Rather, it is a question of balancing the modifiers so that the end-result will be not only in accord with nature, but also pleasing to the eye.

FORM

It is convenient to think of an irregular form as defined by different outlines depending on the point of observation. The forms of anterior teeth may be considered conveniently from three viewpoints: labially, proximally and incisally. The visible outlines should be harmonious from the standpoint of convexity. If one is decidedly convex, all three should possess this characteristic. A flat labial outline as viewed from the incisal end of a tooth, for example, would appear displeasing if combined with a decidedly convex outline as viewed from the proximal side. Furthermore, the visible outlines of all teeth should adhere to a general scheme or motif so that teeth of rectangular outlines and flat surfaces will not be used with teeth which tend toward the spherical type.

An analysis of available artificial teeth as compared with natural ones shows that we are in need of better tooth forms in our work. Perhaps accurate machine copies of natural teeth will be developed for the discriminating.

The decision of how much curvature to introduce into the outlines is made on the basis of the curves of the face. Flat surfaces and straight lines in the face call for flat surfaces and straight lines in the teeth, and curves in the face require curves in the teeth. This requirement of harmony in degree of curvature is an important one. It is not to be confused with the typal form hypothesis, for example, that tapering faces call for tapering teeth. Observation will verify the fact that many of the most pleasing effects with either natural or artificial dentures are found in tapering faces with rather square type teeth. Both incisal and proximal wear tend to change teeth more and more toward the square outline. Recession of proximal gum tissue also makes teeth appear more nearly square. The three outstanding esthetic requirements under this heading seem to be that the forms shall not deviate too far from the average, that the forms shall be similar in their degrees of curvature and that the forms in and of themselves shall be beautiful.

COLOR

The three dimensions of color should be kept in mind. Imagine looking at a gold-fish bowl filled with clear water and sitting in front of a white background in a strong light. If we pour into the water

a few drops of red dye, for example, the water takes on a red hue. Then if we pour in more of the red dye, the hue becomes more saturated. No matter how much of the same red dye is added, the hue continues to be red. The more of the same dye we add, the redder the water appears. Thus, the quality or the position on the spectrum gives the hue, and the amount of hue gives the degree of saturation.

We could perform the same experiment with any color on the spectrum. By adding more and more orange dye, for example, we produce greater and greater saturation of the orange hue. Hue and saturation are the two qualities by which we distinguish one color from another. Besides the two qualities of hue and saturation, all visible substances possess a third quality. Some call it brilliance; others refer to it as shade. In the example of the fish-bowl with colored water, adding black to the water would decrease the brilliance or increase the shade. The brilliance could also be decreased by cutting down the illumination.

These three qualities or dimensions of color apply to teeth. Tooth substance possesses hue, saturation and brilliance. The brilliance of a tooth may be decreased by the addition of black, by roughening the surface so that less light is reflected to the eye or by decreasing the illumination. As we have little or no control over the source and intensity of light after the patient leaves the office, our means of decreasing the illumination consists in the irregular arrangement of the teeth, which causes shadows; or in placing them farther back in the oral cavity where less light will reach them.

It is evident that a tooth may possess the correct hue but may have too great saturation of that hue or too much brilliance. Again, the saturation and brilliance may be correct, but the hue may be wrong. Pleasing effects are to be had only when all three dimensions are satisfactory. It is difficult to say which of the three is most important, but it is fortunate that all three need vary within rather small limits in teeth.

The so-called shade guides furnished by tooth manufacturers are really guides for hue, intensity and brilliance, and doubtless a logical system will some day be developed for use in tooth selection. The system will necessarily incorporate the factors of hue, intensity and brilliance in different areas according to the distribution of dentin and enamel in human teeth.

Dentin has a hue the spectral band of which is near the yellow, saturation weak and brilliance high. Hue, saturation and brilliance are fairly constant. When protected by enamel, it does not differ greatly from individual to individual, from youth to age or from tooth to tooth.

On the other hand, enamel (practically without hue) may decrease markedly in brilliance with advancing years. With respect to the color effects produced by the enamel, two facts are of importance: (1) the enamel may take up tobacco or other stains, thus losing brilliance, and (2) its thickness varies in different parts of the crown, which permits varying amounts of dentin hue to show through.

TRANSLUCENCY

If the enamel were completely opaque, its varying thickness would have no effect on the appearance of a tooth. However, its translucency makes visible the ivory hue of the underlying dentin. Especially near the incisal edges where there is no underlying dentin, its translucency decreases the brilliance of a tooth as seen against a dark oral cavity or increases it if the oral cavity is lighted. While much of the gray appearance is at the incisal or occlusal portion of a tooth, the enamel also encircles the crown, so that the proximal portions too should have the same gray character. Obviously, artificial teeth appear unnatural when the gray band is distributed merely across the incisal third of a tooth without being carried up the

sides. Naturalness of appearance is to be gained not only by choosing a general color which is suitable for the patient's face, but also by the placement of color in each tooth according to the distribution of the hue and translucency of the structural elements of natural teeth.

The almost complete absence of hue in the enamel structure gives it a grayish appearance where not backed by dentin. On this account, the average upper central incisor presents a gray incisal tip, the lateral still more gray and the cuspid considerably less. Because of the comparatively small amount of enamel covering, the ivory hue is more in evidence on the cuspid, and this tooth therefore is said to be yellower than the incisors. As the buccal cusp of the first bicuspid is usually well covered with enamel, its color appearance is similar to that of the lateral incisor. The gray of the lateral incisor on one side and that of the bicuspid on the other side creates a condition of contrast with the cuspid which makes it appear yellower than it would if standing alone.

The dentin also possesses translucency, but to much less a degree than the enamel. Thus, we have in each tooth a body of slightly translucent dentin of characteristic shape, and a much more translucent covering of enamel of varying thickness at different parts of the crown. The slightly translucent dentin has a characteristic hue, intensity and brilliance; whereas the more translucent enamel is characterized largely by a lack of hue. With the four factors of hue, intensity, brilliance and translucency, Nature produces beautiful effects. In order to produce the desired optical impression, we must control these same four factors.

ARRANGEMENT

Tooth arrangement may be analyzed under three headings: (1) as related to the face, (2) as related to the antagonists and (3) as related to the proximal teeth. The first relation is to be studied from photographs or silhouette records; the second and third are more easily learned from the occluded casts of pleasing natural dentures.

Arrangement as Related to the Face.—The first consideration respecting placement of the incisal edges of upper central incisor teeth is the horizontal line of the lips in repose. The lateral placement on the frontal plane is determined in part by the center line of the face and in part by the center line of the mouth. If the mouth is at one side of the center of the patient's face, the center line of the tooth arrangement may well be fixed between the face center and the mouth center. If the mouth is in the center of the patient's face, the mesial contact points of the upper central incisors may be placed off center slightly to contribute toward the desired degree of asymmetry, which will be discussed presently.

The profile view of the patient's face is considered in analyzing the positions of the anterior teeth respecting (1) their prominence, (2) the position of the incisal edges of the upper teeth, (3) the inclination of the teeth in the sagittal plane, (4) the horizontal overbite (overjet) of the anterior teeth and (5) the thickness of the upper and lower labial bands of the dentures. With a fixed degree of jaw separation, the lip contours depend almost entirely on these five conditions.

As just indicated, the labiolingual inclinations of the long axes of the teeth determine the labial contours. They are also important from the standpoint of the beauty and naturalness of the dentures themselves. A protruding chin calls for tilting the upper incisors anteriorly at their incisal edges; a receding chin requires tilting them posteriorly. Similarly, lower incisors in protruding jaws tilt inward, and in receding jaws tilt forward. For the average patient, the long axis of the upper central incisor lies parallel with the profile line of the face except when the lateral laps over it, in which case the

central incisor is tilted somewhat lingually at its incisal end.

Arrangement as Related to the Antagonists.—A receding lower jaw must be fitted with teeth of considerable horizontal overbite in order to obtain the best esthetic effect. In this, there is no conflict with the phonetic and mechanical requirements. The actual horizontal overbite may be made to appear less by selecting lower teeth of somewhat lighter shade, for the reason that lighter objects appear closer to the observer than do similar dark ones.

Another factor in making receding lower teeth esthetic lies in the fact that during speech the patient carries the lower teeth to the necessary forward relation to the upper ones in order to make the speech sounds. Speech thus tends to reduce great horizontal overbites as it does also great vertical overbites. The latter fact is fortunate from the esthetic standpoint because it shows that there is no esthetic reason for deep vertical overbites. Even if we use it in artificial dentures, the patient opens the jaws in speech to a point where it disappears. This means that vertical space between opposing teeth, both anterior and posterior ones, appears natural. It follows that the overlapping of upper incisors and upper buccal cusps over the lower teeth in centric occlusion is not an esthetic requirement.

The incisal edges of the teeth have characteristic forms as related to their antagonists, but in spite of great complexity in this respect, the condition does not offer a serious problem to the prosthetist. After the twelve anterior teeth have been arranged, it is necessary only to cause the upper to chew against the lower on the articulator with interposed abrasive paste and the characteristic incisal edges are produced. On analysis, incisal edges thus formed will be found to bear a striking similarity to the incisal edges of natural teeth in like positions. After this "chewing" into characteristic forms, the incisal edges may be channeled with small mounted stones in imitation of the natural depressions of exposed dentin.

Arrangement as Related to the Proximal Teeth.—Asymmetry and irregularity should be introduced into the arrangement to more or less definite combinations, greater irregularity in lower than in upper arches being desirable. Mere irregularity is not necessarily esthetic, and there are only certain types of irregular arrangement which we may safely permit ourselves. The most practical and the most definite means of producing satisfactory arrangements of dental arches is to have available during the "setting up" procedure several sets of casts made from mouths in which the natural teeth were both esthetic and appropriate. Facial type should be matched with tooth arrangement type either by means of photographs or by a memory image. An analysis of the several types would be without much value unless more nearly complete than would be possible in a paper on art factors. The subject deserves a profusely illustrated paper by itself. It may be dismissed here by saying that we should copy Nature's denture compositions virtually in their entirety instead of introducing irregularities at random.

THE GUMS

One of the neglected phases of art in full denture construction is the contouring of the gums. When only opaque denture base materials were available, no amount of study and experiment could produce a natural appearance. With the use of translucent materials, gum contouring is worthy of more attention.

In healthy mouths, Nature covers the gingival portions of the teeth in characteristic manner. The comparative prominence of a tooth in a row, as well as the comparative prominence of a portion of the tooth, influences the gingival contours. The most prominent tooth in a row has the highest gum line and this line is high-

est on the most prominent part of the tooth. One reason why the upper lateral incisor usually appears shorter than the central at the gingival end is that the gingival portion of the lateral incisor is depressed and therefore more of it is covered with gum tissue. Because the upper and lower cuspids are prominent, not so much of their gingival portion is covered by the gum. On the upper first bicuspids, the gum is lower than on the cuspids.

The rotation of a tooth about its long axis changes the gingival line. Thus, if an upper central incisor faces mesially, the highest point of its gingival line will be on the distal half of the labial surface. If it faces distally, the highest point will be on the mesial half. Because the middle portion of the labial surface is somewhat flattened, if the central incisor faces straight forward the gingival line extends sharply upward at the mesial third of its extent and is slightly curved across the middle third and sharply downward at its distal third. On the other hand, the cuspid, being more nearly cylindrical in form, has a gingival line which is more nearly even in curvature. As in the case of tooth arrangement, with gum contouring casts of natural dentures should be used as guides. Because of the characteristic contours associated with tooth arrangement, it is wise, when using a given tooth arrangement, to copy the gum contouring found on the same case.

Natural gum colors vary considerably. As a rule, dark-skinned people have an element of purple in the gum hue which is almost absent in the blond type. Perhaps of greater importance than the exact hue of the gum is its degree of translucency. Too great translucency introduces too much shade in the gum except where it is backed by the tooth. The typical collar on the porcelain tooth, on the other hand, shows through a material of too great translucency, producing a light area which is not natural in appearance. This difficulty may be overcome by beveling the porcelain collar where the gum material is thin, or by grinding off the collar.

TABLE 3.—ESTHETIC NORM FOR TWELVE ANTERIOR TEETH*

Median line	In center of face
Incisal line of central incisor	Even with rest lip line
Form	Square tapering
Hue	5D Justi, 16TC or 16 Universal
Sagittal inclination of upper central incisor	Vertical
Rotation on long axis	Labial surfaces to fall on even curve
Vertical overbite	1.0 mm.
Horizontal overbite	4.0 mm.
Incisal wear of upper teeth	3.0 mm.
Incisal wear of lower teeth	2.0 mm.
Width of upper six	44.6 mm.
Width of lower six	35.4 mm.
Width of upper central incisor	8.2 mm.
Length of upper central incisor	9.0 mm.

*For the average face of about 148 mm. width, this table offers a safe standard for both selection and arrangement of the anterior teeth. Some operators will find it convenient to have a selection and arrangement of this kind ready to test in the patient's mouth in order to note the desired changes in all directions.

THE ESTHETIC NORM

By means of some standard, one can make deviations with greater precision. If a composite picture can be formed from a large number of average cases which are pleasing and natural in appearance, it can be used as a standard of

comparison. If it is suitable for the greatest number of cases, we may well call it the esthetic norm. Such a norm would best fit the average person of medium color, medium age, etc. The more specific we are in describing the norm, the more vulnerable does this norm become to criticism, but perhaps the more useful it may be. Each denture worker may set up his own norm with the idea of altering it from time to time in the light of his experience. Table 3 is merely suggestive.

With the esthetic norm as a starting point, some suitable combination of factors is more readily found. For the same average type several years later, greater incisal wear would be introduced, the brilliance of the teeth decreased and slight gingival recession imitated. For patients with sandy complexion, a bit of red would be added to the teeth. For patients with receding chins, the horizontal overbite would be increased. For patients with broad faces, the tooth width of the norm would be increased.

ASYMMETRY

Perfect symmetry of teeth is so rare in nature that its presence in artificial dentures excites suspicion. The secret of introducing asymmetry lies in making it slight but multiple, because that is Nature's way in cases of pleasing compositions. One upper central incisor may be made different from the other in several particulars, but it is safer to produce most of the asymmetry in the upper lateral incisors. With a given tooth on the right side, the left one may be made narrower, shorter, more nearly round, smoother of surface, grayer, less saturated in hue, more depressed at the gingival portion, with less curvature of the gum line, more prominent at the incisal edge and more rotated on its long axis. Here are ten phases of asymmetry which may be introduced into the composition, although it is not necessary to use so many. It is important to avoid extreme departure in any one particular, although, in the case of upper lateral incisors, considerable variation is permissible in both size and form.

CONCLUSION

The study as outlined here leads us to the conclusion that there is a practical application of the analysis of art factors in full denture construction. Such analysis makes useful the three-step procedure of (1) establishing the norm, (2) departing from that norm in the directions required by a study of the face and (3) introducing suitable asymmetry. With the aid of some such well conceived plan, the denture worker is able to produce esthetic masterpieces.

200 West Fifty-Ninth Street.

PREVENTIVE MEASURES IN PERIODONTOLOGY

By James E. Aiguier, Ph.G., D.D.S., F.A.C.D., Philadelphia, Pa.

WHEN considering preventive measures in periodontology, we automatically turn to the etiologic factors in the pathologic conditions which may arise in the attachment apparatus of the teeth. We must classify and understand these factors and then discuss each of them separately, projecting methods and means to neutralize their effect or prevent their onset. Following the methods employed in general pathology, we may differentiate between predisposing factors and exciting causes of disturbances of the periodontium:

A. *Predisposing factors.*

1. Deficiency diseases: avitaminosis and other dietary conditions.
2. Metabolic diseases: diabetus mellitus and thyroid conditions.
3. Venereal diseases: syphilis.
4. Circulatory disturbances: arteriosclerosis, myocardial weakness and cardiorenal conditions.
5. Blood dyscrasias.
6. Pregnancy.
7. Heredity.
8. Allergy.
9. Endocrine imbalance.

B. *Exciting causes.*

1. Soft deposits on teeth.
2. Hard deposits on teeth.
3. Bacteria: (a) fusospirochetal group; (b) pyogenic cocci: streptococci and staphylococci; (c) leptothrix (calculus).
4. Chemical agents: lead, bismuth, mercury, phosphorus, tobacco, alcohol and occupational chemicals.
5. Irregularities in position of teeth.
6. Caries.
7. Occlusal trauma.
8. Faulty dental work:

Operative dentistry: Restorations not fillings; use of rubber dam and separators.

Crowns and bridgework: Overhanging crowns and overloaded abutments.

Prosthesis: Clasps, improperly designed dentures and ill-fitting dentures.

Orthodontia: Bands and arch wires.

Oral hygiene: Improper instrumentation (children and youths).

Overmedication.

Removal of teeth, without replacement.

9. Mechanical cleansing of teeth by patient with toothpick or dental floss.
10. Irradiation: The use of roentgen rays and radium in the treatment of malignant disease in the mouth.

When the patient presents himself, he is told that our first procedure is a prophylactic treatment. He is shown the condition of the gingivae by means of a hand mirror and each of the following conditions is explained: the presence of salivary calculus, congestion of the tissues, with the resultant change in color, swelling and rounding of the edges of the gingivae and the depth of the pockets.

If he has discovered a cavity or has an aching tooth, we explain that it is impossible to carry on restorative work with the existing mouth condition and he is assured that any emergency work will be taken care of immediately.

Prophylactic treatment is then explained: the removal of calculus, the polishing of the teeth and the treatment and massage of the gingival tissues. When

(From the School of Dentistry, University of Pennsylvania.)

(Read before the Section on Periodontia at the Seventy-Ninth Annual Session of the American Dental Association, Atlantic City, N. J., July 13, 1937.)

Department of Oral Hygiene, School of Dentistry, University of Pennsylvania.

Guard your health by keeping the mouth clean

1. Brush your teeth at least twice a day - in the morning and before retiring; use tooth paste or powder. The teeth must be clean and free from food particles before going to bed.

2. Brush two minutes by the clock. Be sure to brush the gums. A fast light stroke is best. Change the brush when bristles lose their stiffness.

3. Use two brushes; alternate to allow bristles time to dry. Use a small tooth brush as shown in figure #1 - two rows of tufts set fairly wide apart, bristles 1/2 inch long.

4. Care of brush: Wash thoroughly with soap and water after using; hang up to dry in sunshine, if possible.

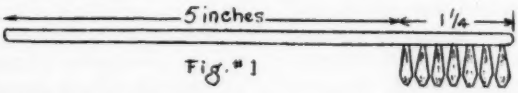

Fig. #1

Tops of teeth or grinding surfaces, Fig. #2. Brush the teeth with a vibratory movement (not moving the brush more than 1/8 of an inch in each direction) on the surfaces on which you chew so as to remove the food particles.

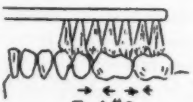
Fig. #2

Between the teeth. Fig. #3. Place brush on side of teeth with side of bristles against the edge of the gums, the tips of the bristles pointing toward the biting surfaces of the teeth. With slight pressure force the bristles between the teeth and give the brush several vibratory movements not moving the brush more than 1/8 of an inch in each direction. This massages the gums as well as removes the food particles from between the teeth. Move the brush to the next position and repeat the motion. Care should be taken to enter every space between the upper and lower teeth from the side toward the tongue and from the side toward the cheek.

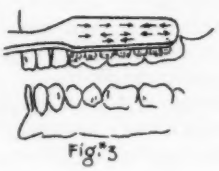
Fig. #3

Upper teeth. Fig. #4. Grasp the tooth brush handle firmly with the bristles pointing upward and place the tooth brush in the mouth between the cheek and gums as far back as the last tooth, laying the sides of the bristles against the gums. Then sweep downward over the gums and teeth by rolling the handle of the tooth brush and wrist inward. Repeat this in the same location several times until the teeth are clean, then move the tooth brush forward to the next group of teeth not reached by the first position and continue until all the outer tooth surfaces are cleansed and the gums massaged. Clean the inside surfaces of the upper teeth in the same manner.

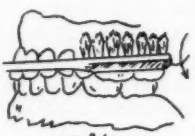
Fig. #4

Lower teeth. Fig. #5. The lower teeth are cleaned similarly except that it is of course necessary to turn the ends of the bristles downward before placing the brush in the mouth and laying the bristle part of the brush against the gums. Then sweep upward over the gums and teeth in each location as often as required. Clean the inside surfaces of the lower teeth in the same manner.

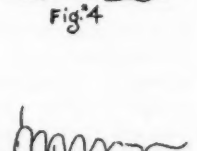
Fig. #5

After brushing the teeth it is of great importance that the mouth be thoroughly rinsed with luke warm water forced back and forth between the teeth several times.

Dental floss is of value in helping to prevent the formation of cavities on the surfaces touching each other. Carefully draw it back and forth between two teeth, but do not injure the gums.

Fig. 1.—Illustrated chart giving specific instructions to patient.

this is completed, the mouth is charted for caries and necessary corrections are made to prevent periodontosis.

Treatment is started and one hour is devoted to each appointment as long as is necessary to get the mouth in good condition.

In every case, enough time is allowed at each appointment to teach the essentials of home care of the mouth, explaining the use of the toothbrush and mouth care in general, as it is important to have the patient understand his responsibility, and not throw the entire burden on the dentist.

In many instances it is only possible to carry out instrumentation of the max-

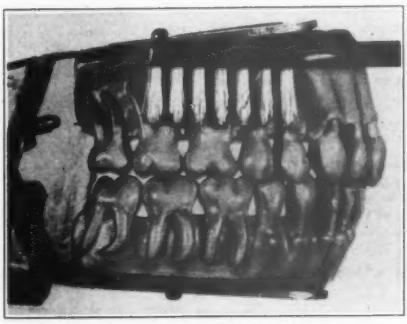

Fig. 2.—Demonstration of use of toothbrush on typodont.

illary teeth or the mandibular teeth, and in extreme cases not all of either at this initial appointment. At this time, the patient is informed that the instrumentation may cause some discomfort and that this may be relieved by holding warm salt water in the mouth at definite intervals, using one-half teaspoonful of salt to a full glass of warm water and holding each mouthful one-half minute. In teaching the patient to brush the teeth, we use a new toothbrush and brush his teeth while he watches in the hand mirror. Then he must carry out the procedure to our satisfaction.

The most desirable type of toothbrush is described, and the number needed, the kind of dentifrice to be used, the care of the brush after each use, the number of times a day brushing should be carried out and time devoted to each operation are indicated.

It is advisable to have a printed chart with illustrations and specific instructions to give the patient, as otherwise he will not remember all that has been said.

We use the chart shown in Figure 1, which can be mimeographed at little cost.

The toothbrush is labeled and kept in the office for future demonstrations. The patient is advised to have a number of brushes on hand and to change frequently, as the condition of the brush and proper manipulation will go a long way in maintaining mouth health.

Each time the patient returns, brushing is again reviewed, with actual brushing of the patient's teeth. A demonstration of the toothbrush on a typodont has proved most helpful in showing the various positions and motions. (Fig. 2.)

In some cases, if the gingivae do not seem to respond readily, we advise the use of the harder type of chewing gum after each meal. We routinely advise its use for children as they are inclined to slight their brushing, and we believe that the use of gum will in some measure make up for this and remove food particles from the embrasures and sulci.

On completion of prophylactic treatments, we routinely take full mouth roentgenograms in all cases, explaining to the patient that we may find some condition in the mouth that could not be demonstrated by any other means. Study models are made when indicated, as in irregularity in position of teeth and caries. The case is then studied for predisposing and exciting factors.

PREDISPOSING FACTORS

Deficiency Diseases. — Avitaminosis from a lack of vitamin A may affect the

SCHOOL OF DENTISTRY—UNIVERSITY OF PENNSYLVANIA
PHILADELPHIA, PA.

PROTECT TEETH BY ADEQUATE DENTAL CARE AND PROPER FOOD

Good nutrition and a well balanced diet are fundamental for dental health at all ages.

TO BUILD SOUND TEETH foods must provide adequate calcium and phosphorus in good proportions and liberal amounts of vitamins D, C and A.

TO MAINTAIN SOUND TEETH AND HEALTHY GUMS these same foods are necessary.

The following table lists the most important foods for health:

TOOTH BUILDING AND TOOTH PROTECTING FOODS	DESIRABLE AMOUNTS	MINIMUM AMOUNTS	CHEAPEST SOURCES
MILK * Supplies—Calcium Phosphorus Vitamin A Vitamin D in varying amounts	1 quart daily for all growing children, expectant and nursing mothers 1 pint daily for each adult	Daily— 1 quart for expectant and nursing mothers and all children under 2 years 1½ pints to 1 quart for children 2 to 12 years 1 quart for children 12 to 18 years ½ pint for adults	Grade B pasteurized Evaporated Milk Dried Milk Powder
LEAFY VEGETABLES Supply—Calcium Phosphorus Vitamins A, C, D in varying amounts	2 to 3 servings daily for adults and children over 6 years 1 to 2 servings daily for younger children Salads are best	1 serving raw at least three times a week, daily if possible 1 serving cooked at least two to three times a week.	Spinach, Escarolle, Cabbage Beet Tops, Turnip Tops Collards, Romaine Swiss Chard, Dandelions
OTHER VEGETABLES Supply smaller amounts of minerals and vitamins most essential for teeth	1 to 2 vegetables daily besides potatoes and leafy vegetables	At least one vegetable daily beside potatoes and leafy vegetables	Potatoes, Turnips Carrots, Onions Dried Beans, Dried Peas
FRUITS Supply—Vitamins C and A in varying amounts Calcium, Phosphorus } in varying amounts	1 to 2 servings of citrus fruit daily 1 to 2 servings of other fruit daily	Orange or tomato juice daily for all children under 3 Raw fruit at least 3 times a week for others Cooked fruit 2 to 3 times a week	Canned Tomatoes Bananas Apples Oranges under 25c a dozen Others in season
CEREALS Supply—Phosphorus Some Calcium Whole grains are best	Use whole grain bread or cereal at each meal in preference to white bread or cereal	Whole grain bread or cereal once daily if possible	Yellow Cornmeal Cracked Wheat Oatmeal, Rice Macaroni, White Bread
EGGS Supply—Calcium Phosphorus Vitamins A and D	1 daily for each child and adult	3 to 6 a week for children under 6 years 3 to 4 a week for others	Storage Eggs Fresh Eggs in spring and summer
MEAT AND FISH All kinds supply phosphorus Liver, oysters, clams also supply calcium and vitamin A	Meat or fish daily for children over 6 and adults	2 to 4 times a week	Stewing Cuts of Beef and Lamb Pork and Lamb Liver Canned Salmon, Dried Cod Fish
CHEESE Supplies—Calcium Phosphorus Vitamin A in varying amounts	Use once or twice a week in addition to or as a substitute for meat	Use once or twice a week in place of meat	Cottage Cheese Domestic Cheese—under 25c a lb.
BUTTER Supplies—Vitamin A Some Vitamin D	Use daily on bread and in cooking if possible	Daily on bread for children under 6 and others if possible Other fats for cooking	Tub or Print Butter Oleomargarines from animal fats Cooking Oil, Lard, Suet
COD LIVER OIL Supplies—Vitamins A and D (Concentrates of Vitamins A and D as suggested by physicians may replace cod-liver oil)	As directed by physician. Usually 3 teaspoons daily for children under 2 years. 4 to 5 tablespoons a week for older children during winter	2 to 3 teaspoons daily for children under 2 years 2 to 3 tablespoons a week for pre-school children if possible	Plain Cod Liver Oil by the pint

* Only the dietary essentials most needed for dental health are listed. Each of these foods provides other essentials for good nutrition.

Prepared by ANNA DEPLANTER BOWES, M.A.
In charge of Nutrition Education, Philadelphia Child Health Society.
Lecturer on Nutrition, School of Dentistry, University of Pennsylvania.

October, 1934.

Fig. 3.—Diet chart.

epithelial cells and involve the mucosa of the mouth. Lack of vitamin B may affect the functioning of the nervous system and manifest itself in the mouth. A deficiency of vitamin C may affect the capillary blood vessels and of vitamin D may affect bone growth and, in the adult, cause softening of bone.

Other dietary factors, such as improper intake of carbohydrates or proteins, may affect the periodontium.

Figure 3 shows the chart to which we

refer the patient for proper diet. The dentist should be familiar with, and therefore forewarned against, the various fad diets which are suggested from time to time. He should be well founded in the principles of the balanced diet; but in prescribing a diet for any patient, he should realize the necessity of consulting the family physician.

Metabolic Diseases.—Diabetes mellitus may affect some mouths. We have found in our survey of all cases in the Presbyterian Hospital in Philadelphia over a period of two years that the adolescent patient seldom presents oral manifestations. The uncontrolled diabetic reacts very little to treatment of the gingiva, whereas the one in metabolic balance will show marked improvement.

Venereal Disease.—Syphilis, we know, has a general systemic reaction, lowering the resistance of most tissues in the body, including the attachment apparatus of the teeth.

Circulatory Disturbances.—Arteriosclerosis definitely affects these tissues, and myocardial weakness and cardiorenal conditions are important factors.

Blood Dyscrasias.—These conditions deplete the tissues. In proportion to the severity of the disease, the oxygen and nutritional supply are lessened and there is interference with waste removal.

Pregnancy.—During pregnancy, a definite type of gingivitis may develop and may cause considerable destruction.

Heredity.—Weber and Pastern, also Polevitzky, found a slightly increased evidence of periodontosis among persons belonging to blood group A (N.R.C. classification). As blood types are inherited, these findings indicate that certain persons may be hereditarily or constitutionally more susceptible to periodontosis.

Allergic Diathesis.—This condition, it is asserted, alters the living cell and changes the capacity to resist infection and intoxication.

According to Healy *et al.*, foods, animal emanations, clothing material, bacterial protein, tobacco protein and dust may be responsible for gingival involvement. It is said that the mucous membrane of allergic persons absorbs these proteins more rapidly and they may pass through the oral mucosa and exert their effects locally.

Endocrine Imbalance.—In addition to the imbalance of pregnancy and diabetes, there are other endocrine involvements such as thyroids to which gingival disturbances have been ascribed.

EXCITING FACTORS

Soft Deposits.—Soft deposits on the teeth may cause sufficient irritation to bring about a gingivitis.

Hard Deposits.—The hard deposits cause destruction of tissues if allowed to impinge on them for any length of time.

Bacteria.—The fusospirochetal group are responsible for active infection and may cause destruction of the gingivae and supporting structures.

The pyogenic cocci, that is, the streptococci and staphylococci, are particularly responsible for tissue destruction with pus formation, and there may be in some cases a systemic involvement.

The leptothrix organisms are important as they form a mesh or network upon which calcium salts and débris are deposited, with formation of salivary calculus.

Chemical Agents.—Mercury and bismuth are associated with treatment for syphilis; and the fact that the patient is under the care of a physician makes the condition easy to diagnose.

Lead is usually associated with painting and the patient usually aids in the diagnosis.

Phosphorus poisoning is rarely seen, but is very destructive.

Tobacco combustion produces chemicals any of which in certain persons may cause irritation.

Alcohol in chronic alcoholics causes a

systemic disturbance that may manifest itself in the mouth.

Contact with occupational chemicals many times causes considerable difficulty in diagnosis. I recall a case passing through the clinic: An Italian about forty-five years of age had a gingivitis due to one of the heavy metals. This man was employed in a shoe factory and there appeared to be no evident relation between occupation and gingival condition. After thorough investigation by the consultant, who spent part of a day with him in his work, it was discovered that he used his mouth as a container for the nails. Examination of these showed that they were coated with lead to prevent rusting. The fluids of the mouth dissolved some of the lead, which was absorbed.

Irregularities of the Teeth.—The attention of the patient should be called to this condition and orthodontic treatment advised. Sometimes, one can restore or supplement a tooth form, using inlays or amalgam restorations. This change of tooth form will bring about a protective excursion of the food. Sometimes we resort to jacket crowns and occasionally judicious grinding, especially if a tooth is lingually inclined and the patient may develop a pernicious tongue habit. Irregularities of the teeth may cause uneven deepening of the gingival crevice.

Caries.—Regions where interproximal contact surfaces are destroyed are logical places for food impaction, with resultant destruction of the supporting tissues.

Occlusal Trauma.—This is an important factor. There may be one or several teeth involved. Special care should be taken in adjusting the occlusion, following along definite prescribed lines so as not to destroy the normal contact, if it can be preserved.

Faulty Dental Work.—This is to my mind a most important factor. Let us take up the individual branches of dentistry and see where it may apply.

Operative dentistry: Many times, the dentist is placing fillings and not making restorations. The surfaces are not properly carved for occlusal functioning. Any overhang will eventually cause destruction of the supporting tissues on which it impinges. Oftentimes, the interproximal contact point is neglected. This may permit the packing of food into the interproximal space, with its known results.

The improper use of the rubber dam, clamps and the mechanical separator may likewise cause damage to the attachment apparatus.

Crowns and bridgework: Overhanging of crowns, lack of convexity and contact and also overloading of the abutments are etiologic factors.

Prosthesis: Clasps improperly fitted and those which impinge on the gingivae, also improperly designed partial dentures and those that are ill-fitting are responsible for considerable damage.

Orthodontia: The practitioner may disregard the supporting tissues in applying bands and arch wires.

Oral Hygiene: Improper use of instruments in prophylaxis, especially in children and young patients, many times permanently destroys the delicate epithelial attachment.

Removal of teeth: When teeth are removed and replacement is not made within a reasonable time, irregularities and occlusal trauma result, with the inevitable sequelae.

Overmedication: Many dentists make a practice of overmedication. Thus, the reparative ability of the tissues is reduced. We must learn that the least amount of a drug that will be effective is all that is desired.

Mechanical cleansing of the teeth by the patient: Improper use of toothpicks, dental floss or any instrument may prove destructive to the supporting tissues.

Radiation: When roentgen or radium therapy is used in malignant disease of the mouth, the periodontium suffers considerably.

PROCEDURE IN PROPHYLACTIC TREATMENT

The instruments used (Fig. 4) were McCall curets 5R and 5L, Hutchinson scalers No. 15 and 16, Julian Smith scalers No. 3 and 4, Special scaler No. 101 and Special scaler No. 102. Instruments should always be sharp. If the operator cannot satisfactorily sharpen them or has not the time, they should be turned over to one who can do this work.

An antiseptic solution with some analgesic properties should be used to dip instruments into before each application to the mouth. We use phenol, 100 parts, sodium hydroxide, 5 parts, and water to make 1,000 parts sodium phenolate solution.

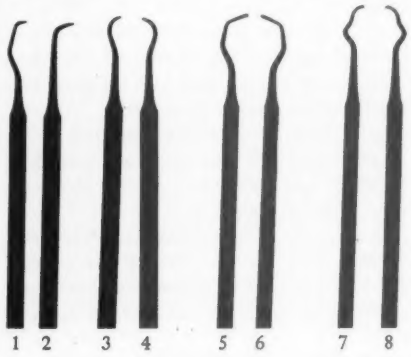

Fig. 4.—Instruments used in prophylactic treatment. Left to right: 1, special scaler No. 101. 2, special scaler No. 102. 3-4, McCall curets 5R-5L. 5-6, Hutchinson scalers 15 and 16. 7-8, Julian Smith scalers 3 and 4.

When dealing with very sensitive gingivae, one should always apply some topical anesthetic, of which there are many recommended. An effective one is 10 per cent cocaine hydrochloride solution. After thorough instrumentation, we proceed to the polishing, using a paste of one part of flour of pumice and three parts of precipitated chalk, mixed into a paste with glycerin and flavored with some pleasant tasting mouth wash. Thus, we avoid the flying pumice and we have an effective, but less abrasive material for use. This paste is kept in a jar with a tight cover which contains a spoon (made from a glass rod), and each time it is needed, enough is put in a dappen dish.

An engine and brush (small pencil type) are used to apply paste, the large wheel and cup brushes being avoided. The engine and brush are always supplemented with a porte polisher and wood point, especially in places inaccessible to engine and brush. All particles of paste are removed, and the soft tissues supporting the teeth are massaged with an apparatus (Fig. 5) with soft rubber cup attached, connected with the engine. With this we use a massage lotion of

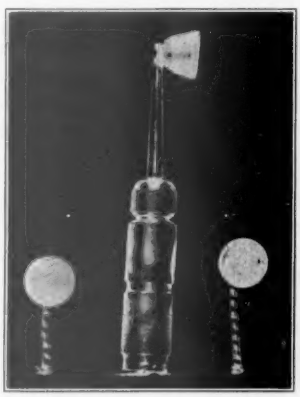

Fig. 5.—Massage apparatus and extra rubber cups.

Alcohol	2 ounces
Glycerin	½ ounce
Oil of peppermint	6 drops
Water to make	4 ounces

MANAGEMENT OF PATIENT

The new patient is told that it may take more than one appointment to put his mouth in condition. If there is considerable congestion, he is brought back at short intervals for massage and treatment. When he is finally dismissed, he is told that he should return at three-month

intervals in order to keep the mouth in condition. Brushing is checked at this time, and the dentist can tell whether the patient is accomplishing what he should.

If the patient goes much over the three-month period, the practitioner can point out to the patient certain places in the mouth that show neglect.

When there are partial dentures in the mouth, we sometimes see patients at shorter intervals for a while and then resume the three-month interval.

MANAGEMENT OF SPECIAL GROUPS

In cases of pregnancy, as soon as we learn of the condition, we immediately start the patient on a monthly schedule for prophylactic treatments during the prenatal period. In this way, we watch for any change in the gingivae or any evidence of caries. If there is any evidence of calcium or phosphorus deficiency, the physician in charge is consulted regarding the essentials for tissue maintenance and protection.

During the period of lactation, the mother is still on a monthly schedule, in order to detect any changes in the gingivae and the teeth and their investing structures.

May I cite a case? The patient had had two children and was on this schedule. Her mouth condition remained very good. We attended her during a third prenatal period, but during the period of lactation, she failed to continue her treatments. Three months later, her mouth showed a severe gingival involvement and marked evidence of incipient marginal caries.

In cases of diabetes mellitus, the patient is ordinarily put on a three-month schedule. When there has been considerable involvement of the supporting structure, a two-month schedule and sometimes a monthly schedule is necessary. After a series of treatments, the time interval may be increased if the case warrants it.

SUMMARY

1. In considering preventive means in periodontology, we must study the predisposing and exciting factors in the pathologic condition, with a view to devising and instituting definite methods of neutralizing their effects or of preventing them.

2. Each case and its attendant problems must be carefully studied and the patient advised of the prognosis.

3. The patient is told what is meant by prophylactic treatment, the operator educating him to care for the mouth properly and to assume his share of the responsibility.

4. A definite procedure is maintained in carrying out treatment, at all times considering the patient and causing him the least amount of discomfort.

5. A definite routine is adopted in the management of the patient, including methods for special groups, *e.g.*, the pregnant and the diabetic.

6. Finally, we would strongly urge greater care on the part of the general practitioner in the prevention and early recognition of periodontal disturbances.

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Medical Arts Building.

PREPARATION OF THE RIDGES FOR FIXED AND REMOVABLE RESTORATIONS

By Frederick F. Molt, D.D.S., F.A.C.D., Chicago, Ill.

In general, it may be said that a fixed bridge can be more readily adapted to a ridge of unfavorable form than can one of the removable type. Nevertheless, when there is an opportunity to produce an ideal ridge for one or the other type of bridge, this should be visualized and made an objective at the time of extraction.

Although the utilization of surgical principles and procedures—the "surgical removal" of teeth, which was at first received with so much derision—has come to be a generally accepted procedure, by far too large a proportion of "preparations" are those effected by Nature's post-extraction efforts, and they all too frequently fall far short of that desired.

"Natural resorption" as a means of ridge preparation has been vastly overrated. It cannot be directed; much less the eventual result be anticipated. Even after waiting for a long time, during which disuse atrophy has taken its toll, the operator is quite likely to find that the ridge is little nearer the result desired than it was in its immediate postextraction condition. If, on the contrary, he decides not to wait for resorption and at once inserts a bridge, fixed or removable, he may, unless the patient has been led to expect a radical change to occur, be embarrassed by having just that happen. Obviously, it cannot be guaranteed that, after surgical preparation, no change will occur, but it can definitely be minimized and, in a goodly proportion of cases, no marked change is discernible over a period of years.

This comparison is based upon the assumption that the extraction in the "natural resorption" case has been accomplished without undue laceration of tissue or destruction of buccal, labial or lingual alveolar plates. As the open-view procedure makes possible the avoidance of these complications and, by retention of the interdental septa, provides the properly shaped matrix for regenerating bone, it presents, in cases of brittle, pulpless teeth or broken down roots or those weakened by the insertion of crown posts, the only logical method of approach to conserve the ridge.

As a matter of fact, more often than not the bone that is resorbed during a prolonged "resorption period" is that which we should like to retain, and the process margins that we wish to have disappear do not, but remain instead as sharp prominences. Undercuts become, if anything, more marked.

We have apparently outlived the era of fixed bridge pontics carried into open tooth sockets, which invariably caused rapid and excessive resorption as well as being in themselves just additional harbors for bacteria, and have returned to adaptation to the ridge. Therefore, our chief aim is toward esthetic values and comfort.

The removable restoration goes farther in its demands, particularly if it is of the type utilizing attachments of the so-called precision type in which lateral movement is practically inhibited by the accuracy of paralleling. Essentially, requirements are the same as for an ideal full denture

(Read before the Section on Partial Dentures—Crown and Bridge at the Seventy-Third Annual Midwinter Clinic of the Chicago Dental Society, February 16, 1937.)

base, if they are not more exacting. To achieve comfort, the base should be rounding and as broad as the original anatomic formation will permit. Sharp margins, whether on the labial, buccal or lingual plates, should be reduced and rounded, because the effect of a knife-edge of bone under the tissue is to all intents and purposes that of something cutting into the mucosa from without.

Undercuts for either a unilateral or a bilateral restoration should be eliminated as nearly as possible. It is obvious that an appliance snapping into place from above or below has no flexibility to permit of its fitting over a prominence and into an undercut; and if its saddle is not adapted to the ridge, it is at best a makeshift.

Fig. 1.—Extremely large growth, *torus palatinus*, making construction of palatine-bar partial prosthesis difficult if not impossible.

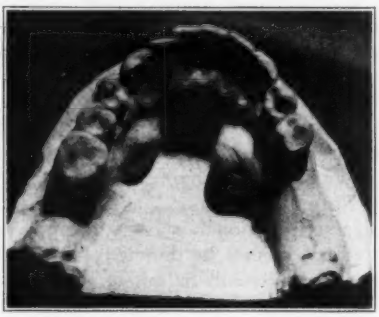


Fig. 2.—Very large exostoses, or osteophytes, around which no satisfactory lingual bar can be fitted.

Finally, there must be ample space for the replacement teeth, and provision must be made for the desirable ridge lap and the proper antagonism with the opposing teeth. In a bilateral restoration, the two ridges should be in all essentials as nearly identical as is possible to provide satisfactory balance. It is not necessary to perpetuate a natural or acquired imbalance if that condition is given consideration in the preliminary study of the restorative problem. Surgery can obviate the use of many intricate and extraordinary appliances by eliminating most of the deterrent factors.

Many conditions are found that are unrelated to the extraction problem or that are present in edentulous areas in which the extractions have been performed a long time previously. Exostoses occur at the median line of the palate, on the buccal surfaces of the maxillae, usually in the bicuspid areas, and on the lingual surface of the mandible. (Figs. 1-2.) They may be so prominent as to interfere with lingual or palatine bars or saddles or both. They are so readily removed that it seems gratuitous to attempt to build around them and unnecessary to let the patient suffer the discomfort that they frequently cause if not removed. A soft tissue base can never be a satisfactory one for a saddle, and whether caused by the presence of an excess of flabby pyorrhea tissue which was left in place or by the continued wearing of a previous and ill-fitting restoration, may and should be reduced to solidity.

Knife-edge mylohyoid ridges may make the pressure of the saddle unbearable, and to cut away the saddle robs the restoration of important bearing and retention. These edges can be smoothed to comfortable roundness. This is also true of the knife-edges occasionally encoun-

tered on the crest of the mandibular ridge or of the small islands of sclerotic bone brought into prominence by the resorption of the surrounding and less dense osseous structure.

Then, to avoid the hill and dale effect produced by recent extractions adjacent to areas of previous extractions, as well as to provide requisite space, proper alinement of the teeth and satisfactory balance, an effort should be made to reduce these areas to a degree of symmetry. This applies as well to the over-large tuberosities which, while not interfering with the mandible themselves, will not accommodate the thickness of the saddle material without reduction.

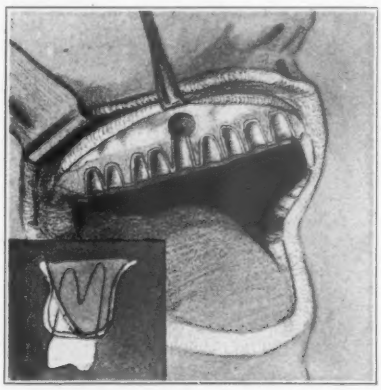


Fig. 3.—Process reduction retaining septa. The cross-section shows ridge shaping to provide for ridge-lap. The second bicuspid area is opened for complete extirpation of the peri-alveolar abscess.

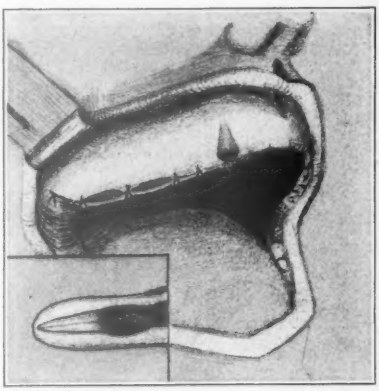


Fig. 4.—Mucoperiosteum replaced, with sutures over septa; reduction of excess tissue at tuberosity.

ALVEOLECTOMY

As the routine of alveolectomy has been given repeatedly, it will be covered briefly:

In the vast majority of cases, block or infiltration anesthesia is to be preferred to general, permitting as it does a field with a minimum of hemorrhage and therefore an unobstructed view, as well as deliberate surgical procedure that makes it possible to accomplish all that has been planned and as planned.

The instruments required, other than those necessary for extraction and curettage, are knives, periosteal elevators, mallet and chisels, alveolar trimmers and files, rongeurs, needle forceps, needles and sutures and scissors.

The operative work is undertaken with as careful attention to asepsis as regards instruments, dressings, operator's hands, etc., as might be associated with surgery in a hospital operating room. There is still an unfortunate tendency to ridicule any effort toward an aseptic régime, chiefly on the theory that complete asepsis is unobtainable and that it is, therefore, rather useless to attempt it at all. This smacks too much of the early days of our profession—of the barber antecedents, perhaps. Even if there may be an unavoidable break in the aseptic régime, any lack of effort to maintain sterile operative procedure is inexcusable. Recent discovery of a mercurial bactericide the use of one dram of which for rinsing the mouth actually insures and maintains freedom from bacteria for four

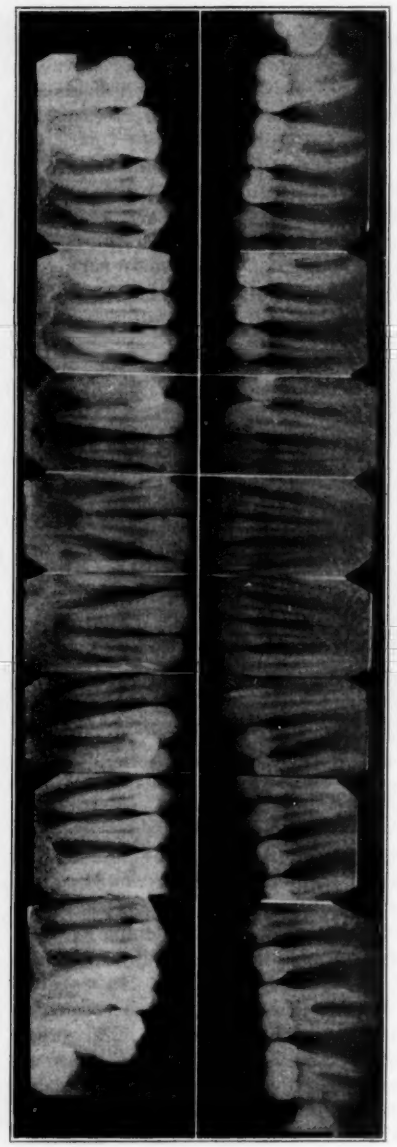


Fig. 5.—Normally calcified bony structure. (McKevitt.)

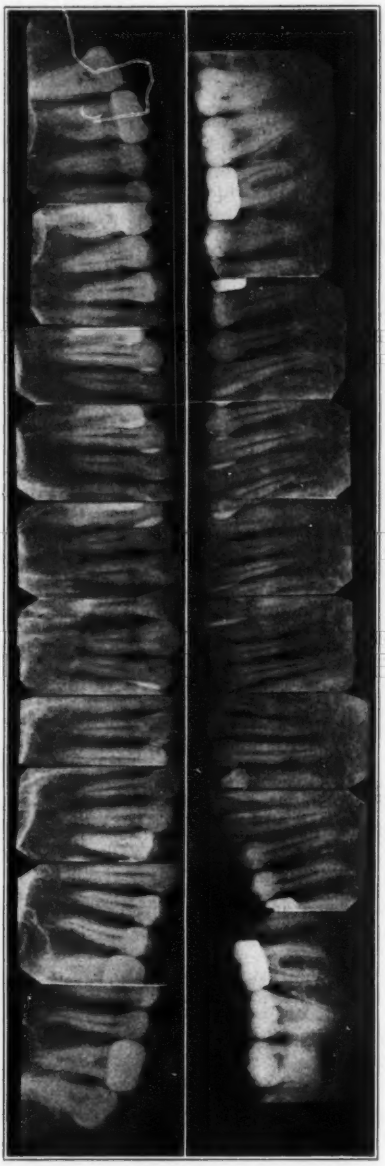


Fig. 6.—Hypocalcified (hypocalcemic) bone. (McKevitt.)

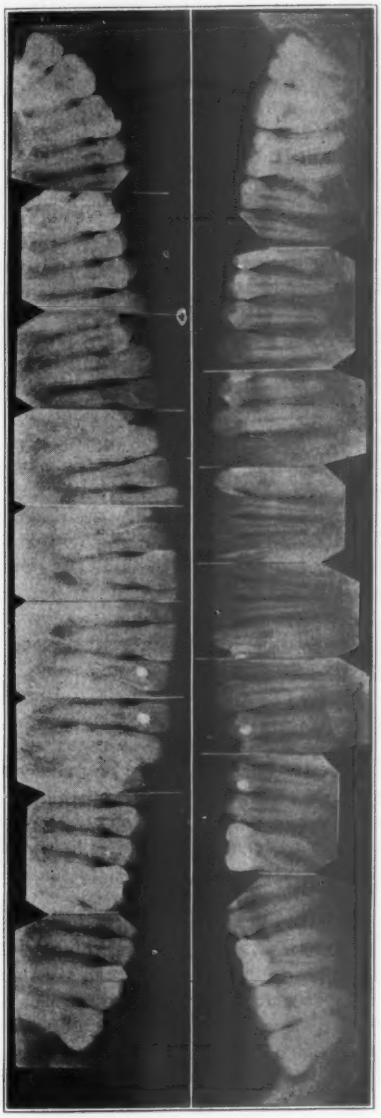


Fig. 7.—Hypercalcified (hypercalcemic) bone. (McKevitt.)

hours removes the last possible excuse for careless operative intervention. If one, therefore, is schooled in the principles of aseptic surgery, there need be no tangible deviation therefrom.

Whether extraction is undertaken first and the alveolar trimming done as a secondary step or the mucoperiosteum is retracted and some process removed as a preliminary to the extraction is determined chiefly by the problem presented. If pulpless teeth are to be removed, two possibilities are present: 1. The teeth may be fractured, removal of the roots becoming much more difficult than the extraction of a tooth that has been exposed. 2. If the outer alveolar plate should adhere to the tooth root, adjacent teeth may be needlessly (and undesirably) denuded; an unfortunate occurrence if these teeth are expected to serve as stable abutments. This is, of course, almost inevitable if the tooth to be removed is hypercementosed, and since, in advanced periodontoclasia, the destruction has invariably been greater on the lingual than on the buccal or the labial aspects, it may all too readily occur with such teeth.

Longitudinal incisions are made following or, in advanced pyorrhea cases, paralleling the gingival line. Lateral incisions are diagonal or curved, seldom straight, and always, if possible, over process that is not to be disturbed, or over a septum.

The mucoperiosteal flap is gently retracted and held back out of the way of operative work. With side cutting rongeur, preferable to the biting rongeur, then with chisels, alveolar trimmers and files, the desired shaping of the ridge is achieved. (Fig. 3.) The septa remain undisturbed, except for the shaping, and act as a support for the replaced flap and as a matrix for regenerating bone. Débris and any existing pathologic tissue having been removed, the flap is brought into place. Before suturing, it may be desirable to run a gloved finger over the area to be sure that no point, margin or under-

cut has escaped observation. If the area is smooth on examination, sutures are inserted from buccal or labial to lingual borders. Sutures are placed invariably over septa to avoid indentation, and great care should be observed to avoid traction on the flap that will lower the mucous fold or bring muscle attachments into prominence. No more sutures should be used than are necessary for retention of the flap. Suture material is optional, my preference being for Luken's No. oo tanned gut, and these, while they will, in most cases, dissolve within a week, are usually clipped and lifted out the second day after operation.

Postoperative care consists chiefly of the application of an ice bag externally.

REMOVAL OF OSSEOUS EXCRESCENCES

The technic of removal of osseous excrescences on the buccal surface of the ridge is essentially the same as the trimming described. In some cases, the incision is confined to such a semilunar flap as would be made for a root resection. The same procedure is utilized in removing sclerotic islands of bone made prominent and painful by adjacent resorption. In removing exostoses on the lingual plate, the incision is made on the ridge crest and the tissue loosened. The flap is held back with a reversed periosteotome held closely against the alveolar plate below the nodule. The chisel is applied above the growth, and, with a sharp tap of the mallet, it is removed, the periosteotome keeping it from dropping out of sight. The fragment is lifted out with the hemostat and the flap replaced. Identically the same procedure is followed in the case of sharp mylohyoid ridge.

With regard to palatal excrescences *(torus palatinus)* a more complicated problem exists. These are usually much too extensive to be removed *in toto*. The incision follows the median line of the palate from the posterior border of the growth to a point well anterior to the growth, with diagonal incisions toward each cuspid from this point. This tissue must be handled particularly carefully as it is exceedingly thin and delicate. Retracted, it may be sutured temporarily to the mucosa laterally or held back by a flat retractor or periosteotome. These excrescences must usually be removed in slices, as one might plane away a board. Occasionally the prolonged chiseling may be lightened by honeycombing the bone to be removed with a surgical drill. In replacing the flap, an excess is usually found and this should be removed. These wounds heal more slowly than any of the others; and for suturing, horsehair or silk may be preferred.

Overlarge tuberosities may be bone, tissue of almost cartilaginous consistency, or both. A curved incision is made slightly lingually to the crest of the ridge, extending anteriorly and posteriorly of the excess. Another incision is made sufficiently in the buccal direction to include the estimated excess of tissue, the line of incision originating and ending with the first one. (Fig. 4.) This wedge of tissue having been removed, the buccal flap is loosened and any necessary bone removed. It is frequently necessary to cut sidewise medially and laterally to remove some of the excess tissue in these flaps, without disturbing periosteum or surface mucosa.

To remove a sharp spine on the crest of the ridge, an incision should be made on the buccal side of this bone and the flap lifted over it. A few taps of chisel and mallet remove the sharp bone. The slight excess of tissue is cut away with scissors and a suture or two are inserted. Much the same procedure is used in removing soft tissue on a ridge, and there will usually be found, in these cases, some sharp spines of bone to be removed.

A comparatively simple procedure, but one that makes for rapid healing, comfort and stability, is carried out when a bicuspid or some other single tooth is to be lost and added to a restoration. A "V" of tissue is removed distally or mesially and the buccal flap slightly

loosened. The sharp prominence at the ridge crest is first removed and then the chisel, flat side down, is directed diagonally buccally to remove the socket margin. A suture closes the "V" and the resorption of this margin need not be awaited.

Obviously, it would be impossible to outline the various small steps that one may take or need to take in order to assure a satisfying result. The only formula is for the surgeon to familiarize himself with the construction problems in restoration and visualize the result that he might anticipate were he himself planning to replace the teeth. A profitable lesson can be learned by wearing a removable bridge and finding out what conditions cause extreme discomfort.

Although it is completely aside from this subject to discuss differences in osseous structure, since this presentation is confined to surgery, that phase cannot be dismissed without comment.

DIFFERENCES IN CALCIFICATION

McKevitt, Becks and others have called attention to the vast differences that exist in jaws and are disclosed by satisfactory roentgenography. McKevitt's[1] terminology, "normal, hypocalcified and hypercalcified," presents a classification that is probably as exact as desired. (Figs. 5, 6, 7.) There will necessarily be gradations throughout these groups, but if, with identical roentgenographic technic, one of two similar ridges shows extreme radiolucence and the other comparative radiopacity, we may logically expect vastly more extensive and more rapid resorption of the first jaw. The radiolucence is due to the presence of fewer trabeculae and, necessarily, of less calcium; a point that is, more often than not, completely overlooked in preliminary study of the case. Whether the hypocalcification may be due to endocrine disturbances, disuse atrophy or some other cause is of little consequence: the situation exists and the fact that such a ridge will not stand up has no relation at all to the method of preparation. The point that should be stressed is that, in order to avoid the consecutive loss of abutment teeth, this ridge should be broad and well prepared, the attachments preferably of the carefully paralleled type and the material used of a kind that is susceptible of frequent rebasing. A loose metal clasp and a saddle, not remade or rebased, will be likely to act as a progressive orthodontic appliance.

No doubt, many of these patients showing demineralization may be recognized by the dentist as in need of medical attention before either physician or patient suspects the condition; but as we have not as yet discovered how to make substantial bone from that lacking in mineral elements, the restorative problem, for the sake of the patient's comfort and the operator's peace of mind, must be adequately studied.

CONCLUSIONS

1. The requirements for fixed bridges and removable restorations are not identical, those for the latter being more exacting.

2. Surgical preparation of the ridge is desirable in most cases, imperative in many.

3. Such surgical procedure is as worthy of meticulous aseptic care as is any other. Rigid asepsis can be maintained.

4. That osseous structures vary widely in density should be given consideration in the study of the individual case.

25 East Washington Street.

1. McKevitt, F. H.: Atrophy and Hypertrophy of Maxillary and Mandibular Alveolar Process and Their Effect on Stability of Artificial Dentures. J.A.D.A., 19:424, March 1932; Osseous Changes in Alveolar Process and Their Effect on Partial Dentures. Ibid., 23:2245, December 1936.

WHAT IS SURGERY'S PLACE IN PERIODONTIA?

By M. H. Garvin, D.D.S., Winnipeg, Canada

ONE must have a clear conception of the problem being dealt with before surgery's place in periodontia can be considered. That problem involves not only diseased oral tissues, but also the health and the economic status of the patient.

Gingivitis, gingival recession and alveolar atrophy, acute and chronic Vincent's infection and periodontoclasia, or pyorrhea, are the most common degenerative processes that affect the supporting tissues of the teeth.

In marginal gingivitis, swelling and inflammation are present; the tissues bleed easily and there are calcareous deposits on the surfaces of the teeth, subgingival and supragingival. If this gingivitis is neglected, the gingival epithelium becomes detached, the periodontal fibers are separated from the cementum and a pocket is formed. These pockets are characteristic of periodontoclasia and usually exude pus. There may be but one pocket in the mouth or every tooth may be involved.

It is not the intention to deal with gingivitis, Vincent's infection or alveolar atrophy, the last generally supposed to be of systemic origin, but with that form of periodontoclasia in which there is definite pocket formation.

I would have you picture that extensive infection which is very common among adults in this country and which obviously undermines the health, since the total area of these pockets is often very great and, being bathed in pus, organisms are forced into the circulation whenever any effort is made at mastication.

Fish[1] points out that there is a much greater area of toxic absorption in the case of definite pyorrhea than there is from the apical canals of a few infected "dead" teeth and that the risk of escape of organisms into the blood stream from an apical lesion is not so great as from a pyorrhea pocket, since the former lesion is less liable to mechanical interference unless the tooth is loose or the root canal open. On both counts, therefore, an infected pulpless tooth is less dangerous than infected periodontal sulci. Fish further emphasizes the fact that in addition to the dangers of toxic absorption and the escape of streptococci into the blood stream, we have also in pyorrhea the obvious danger of swallowing infected matter, whereupon the streptococci may find habitation in the crypts of the intestinal canal.

ECONOMIC PROBLEM

I have described briefly the mouth condition as it so frequently presents itself and have drawn attention to the possible serious consequences to the general health if treatment is neglected. Now I would have you bear in mind that there is an economic side to this problem which cannot be overlooked. Frequently, dentists have told me that patients have consulted them who required extensive dental service and who simply could not afford to pay for the service, even though the fee was most moderate and lenient terms of payment were suggested. The picture is a very common one in these days.

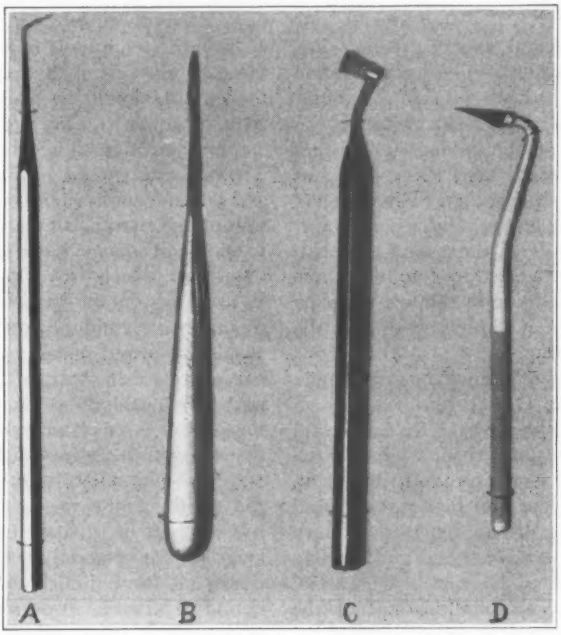
(Read before the Section on Periodontia at the Seventy-Ninth Annual Session of the American Dental Association, Atlantic City, N. J., July 13, 1937.)

1. Fish, E. W.: *J. Brit. D. A.*, 61:336, September 15, 1936.

These cases are handled in various ways, such as by extracting the teeth and by inserting simple fillings in the most urgent cavities, and I submit that, in many of these cases, no attention is given the periodontal lesions, chiefly for economic reasons. For instance, a patient who has $50 at his disposal states that he would like a small bridge inserted. The dishonest dentist may render this service instead of pointing out the absolute necessity of first placing the mouth in a condition free from infection. Elimination of infection from the mouth means treating periodontoclasia when it is present or extracting the involved teeth, and to neglect to do this means jeopardizing the health of the patient.

This problem does not arise often enough to be a source of serious consideration to the specialist, whose practice is composed largely of well-to-do people, but it does arise frequently in the experience of the average dentist, whose practice is composed largely of the great middle class, with many, perhaps, from the lower income groups. To these men and to this problem, I address any remarks I have to make on the subject "What Is Surgery's Place in Periodontia?"

When dental periclasia pockets become several millimeters deep—and frequently we are dealing with pockets 8 or 10 mm. or more in depth—it is essential that they be eliminated if the patient is to enjoy good health and avoid the risk of a secondary infection, which so often occurs.



A, periodontal probe. B, short-bladed lancet. C, Young's medicator. D, Drake stimulator.

Of course, it is wise, if at all possible, to secure roentgenograms of these cases, but it should be remembered that a pocket is determined by the lack of attachment of the soft tissues to the tooth and not entirely by the amount of alveolar bone which has been destroyed. For this reason, it is necessary to undertake a thorough clinical examination, using

to explore all pockets a periodontal probe as shown at A in the accompanying illustration.

Before dealing with pockets, a prophylactic treatment should be given, hopelessly involved teeth should be extracted and undue trauma on any particular tooth or teeth should be relieved. Overhanging margins on fillings should also be removed, although this can usually be taken care of at the time of operating on the pockets.

OPERATIVE PROCEDURE

There are several ways of getting rid of periclasia pockets. The conservative method, which involves skilful subgingival curettage, has as an objective the reattachment of the periodontal tissues to the root surfaces and the consequent elimination of the pocket. This involves a most exacting technic and is disappointing in the hands of the average dentist. The alternative procedure is to treat these pockets surgically or to remove them by electrocoagulation, which is still in the experimental stage.

Several types of surgical operation may be performed. One is the well-known flap operation, laying back the labial and buccal alveolar gum tissue and thus exposing the involved roots of the teeth. The root surfaces are then curetted and all diseased tissue is removed. Sharp edges of bone are smoothed and the flap is drawn back to position and sutured. There are various modifications of the flap operation, but in principle they are very much alike and the results obtained are all that could be desired. This method is definitely superior to the conservative method of treatment if the pockets are of any considerable depth.

There is another method of removing these pockets which, in my opinion, has a definite advantage over any of the other methods and that is gingivectomy, or gum resection. In this method, the gum tissue is cut away to the depth of the pocket in most cases, the roots are curetted, all diseased tissue is removed and the area is then covered with a surgical paste in order to protect the field of operation. A short bladed lancet, shown at B, is used to avoid any injury to the lips or cheeks.

If this operation is properly done, and it is not difficult, and if directions as to after-treatment are followed by the patient, the results are most satisfactory and have been accomplished in much less time than any of the other operations. This, I submit, is a most important matter in dealing with the large economic group to which I referred in the early part of this paper.

If all the teeth have to be operated on, those on one side of the maxilla, distal to the cuspid, should be operated on first; then, a day or two later, the lower teeth on the same side should be operated on. These tissues should be allowed to heal and become comfortable before the other side of the mouth is touched so that the patient will always have one side of the mouth on which to masticate his food. In working on the anterior part of the mouth, we should always operate from cuspid to cuspid, never terminating any one operation in the median line. If this plan is followed, the psychologic effect on the patient is much more satisfactory. In the case of the upper anterior teeth, it may be wiser not to remove all tissue to the depth of the pocket, but rather to remove part of it, then thoroughly curet and aim for a certain filling in of new tissue, all for esthetic reasons. There is bound to be some absorption in any form of treatment when much alveolar bone has been absorbed, and I do not believe that the esthetic result in the case of gingivectomy is markedly inferior to that of other types of treatment after the tissues are thoroughly healed, granting that the operation has been carefully and artistically performed.

If acute bacterial invasion is a complicating factor and one wishes to use drugs in the treatment, application can be most successfully made by dipping a cotton pledget in arsphenamine glucose solution 10 per cent, as suggested by S. L. Rosen-

thal, for Vincent's organisms, and in metaphen or 5 per cent aqueous solution of mercurochrome when a steptococcicide is required, the drug being placed in a rubber cup, shown at C, and the operator working under the gum margin as suggested by Vastine.[2]

RESULTS

In spite of many statements by prominent periodontists to the contrary, I do not find, as a result of this operation, that the roots of these teeth become unduly sensitive. In the few cases wherein this occurs, it can be overcome by painting with silver nitrate followed by iodine in the posterior parts of the mouth where discoloration will not be offensive, and by some drug such as zinc chloride or formaldehyde in the anterior part of the mouth.

This operation can be performed with little or no pain either during the operation or afterwards and the patient's business is not interfered with in any way. The normal mastication of food is not interrupted. The time spent in operating is very much less than in the case of conservative treatment, and the tendency for recurrence is also very much less. In fact, recurrence need not be considered seriously if directions are followed by the patient, these directions in most cases being simple. My only exceptions would be in the case of serious systemic diseases.

DIRECTIONS TO PATIENTS

As regards directions, the patient should understand that his teeth and gums must be properly brushed and stimulated regularly. In addition to the use of the toothbrush, following largely the well-known Charters' method, it is imperative that some form of interdental stimulator be used by the patient night and morning in order to maintain a normal, hard cuticle. These stimulators are made of ivory, wood, rubber and other materials. I prefer the ones made of rubber, as shown at D, and have found them most satisfactory.

These stimulators should be pressed firmly into each interproximal space and so vibrated that the epithelium at these points is stimulated and hardened. Of course, the use of this instrument two or three times a week is useless. It must be used regularly and thoroughly at least twice a day.

While careful attention to these details prevents recurrence, it is a wise and a safe procedure to advise regular prophylactic care every three or four months, when any deposit of tartar can be removed, undue trauma corrected, the surfaces of the teeth polished and an examination made for incipient caries. This recall plan will prove more satisfactory if the dentist's assistant telephones the patient at the time agreed on rather than if any other form of reminder, such as a card or letter, is resorted to. Furthermore, the approach should be of a positive nature, taking for granted that the patient wishes to make the appointment, he having already agreed to the plan of being reminded. By no means say "Would you like to make an appointment?" but rather "When would you like to make an appointment?" or "Dr. X could see you on Friday afternoon if that is convenient."

The President of the American Dental Association has wisely suggested that "Prevention" be the theme for this convention. With this thought of how best to eradicate mouth infection caused by periodontoclasia; to get rid of it in the quickest and therefore in the most economical way; to eradicate it with the least possible discomfort and loss of time to the patient, and so to work it out that it will be a simple matter to prevent the recurrence of the trouble, I submit that the surest and best way is to cut away the tissues which form these pockets and then keep the healthy tissue which forms at the seat of operation stimulated and exercised regularly.

314 Summerset Building.

2. VASTINE, A. B.: Subgingival Treatment in Oral Surgery. J.A.D.A., 22:953, June 1935.

DENTAL SILICATE CEMENTS: PHYSICAL AND CHEMICAL PROPERTIES AND A SPECIFICATION*

By GEORGE C. PAFFENBARGER,† D.D.S., IRL C. SCHOONOVER,‡ Ph.D., and WILMER SOUDER,§ Ph.D., Washington, D. C.

FOREWORD

THIS report on dental silicate cements is the culmination of approximately three years of cooperative research work among scientists at the National Bureau of Standards and the American Dental Association research associates stationed at that institution. Each year, a progress report of the work was presented at the annual meeting of the American Dental Association, but publication of these reports was delayed until the research was completed and a tentative specification was prepared so that the complete study could be made public in one report.

In order that the purpose of this paper shall not be misunderstood, the Research Commission deems it advisable to explain again its policy with respect to the use of trade brand names in reports. Here, the silicate cements are identified by code letters because this report is an introductory one giving tests, test methods and data used in formulating a specification which will serve as a standard for evaluating these cements. With this information available, a manufacturer can certify to the Research Commission that his cement will comply with the American Dental Association Specification No. 9 for Dental Silicate Cement. When the manufacturer does this and furnishes information regarding his testing equipment and personnel, in order that the Research Commission may have some knowledge of the manufacturer's facilities to insure production of uniform batches, the cement will be retested for compliance with the A.D.A. specification by its research associates at the National Bureau of Standards. If the cement is found to comply, the trade brand name of the cement and its manufacturer or distributor will be entered on the list of certified materials so that the dentists may know what brands of cement comply with the American Dental Association standard. If the cement fails to comply, it will not be placed on the list.

The data in this report are based largely upon one or at most a few batches of a manufacturer's cement and, as shown in the report, batches of the same brand of cement may vary considerably. The data therefore are applicable only to the batches and shades which were purchased for testing. The Research Commission does not know whether the batches procured for testing are truly representative

(Read before the Section on Physiology, Histology, Pathology, Bacteriology and Chemistry [Research] at the Seventy-Ninth Annual Session of the American Dental Association, Atlantic City, N. J., July 13, 1937. Sections of the report were presented at several dental society meetings during the last three years.)

*A report to the Research Commission of the American Dental Association.

*Publication authorized by the Executive Board of the Research Commission.

†Research associate of the American Dental Association at the National Bureau of Standards.

‡Associate chemist, National Bureau of Standards.

§Principal physicist, National Bureau of Standards.

of the manufacturer's production. Only the manufacturer can assume the responsibility for the uniformity of his output. In view of these facts, the Research Commission requests that neither the numerical data contained in this report nor inferences drawn from the numerical data shall be quoted in manufacturer's advertising or sales promotion activities. Instead, the manufacturer should use data from his own testing laboratory.

EXECUTIVE BOARD,
RESEARCH COMMISSION.

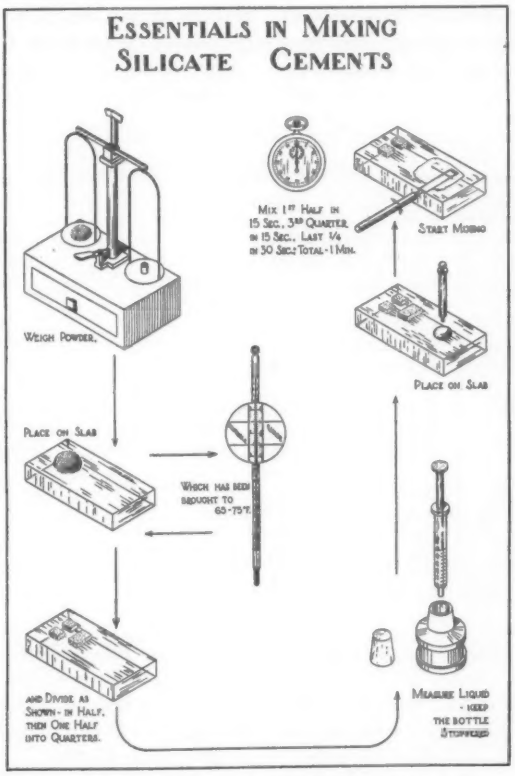

ESSENTIALS IN MIXING SILICATE CEMENTS
WEIGH POWDER.
MIX 1ST HALF IN 15 SEC., 3RD QUARTER IN 15 SEC., LAST 1/4 IN 30 SEC.; TOTAL - 1 MIN.
START MIXING
PLACE ON SLAB
PLACE ON SLAB
WHICH HAS BEEN BROUGHT TO 63-75°F.
AND DIVIDE AS SHOWN - IN HALF, THEN ONE HALF INTO QUARTERS.
MEASURE LIQUID - KEEP THE BOTTLE STOPPERED

Fig. 1.—Schematic diagram of technic employed in making mixes of cement that were used in preparation of test specimens. (This and subsequent drawings are by John R. Beall.)

HISTORY

The first serious attempt to produce and market a silicate cement is credited to Fletcher,[1] who, in 1878, discovered and patented a cement of this type. This cement did not prove to be satisfactory, and it appears that no serious attempt was made to perfect a silicate type of dental cement until about twenty-five years later, when the German chemist Steenbock developed one which was marketed in 1904 by a German dentist Ascher[2] under the name "artificial enamel." Several other cements soon appeared.

The dentist thought that he had the ideal filling material, a durable, esthetic appearing material which could be introduced into the cavity in a plastic state,

and which would then harden sufficiently to resist attrition satisfactorily in the mouth. Consequently, the cements were accepted with immediate enthusiasm and without a proper trial or experimental period.

The belief that these cements were the ideal filling material did not prevail for long. In practice, they began to discolor and to dissolve, and, what was indeed far worse, pulps began to die in the teeth where silicate cement fillings had been placed. Then the pendulum swung in the opposite direction—silicate cements were severely condemned and many dentists refused to use them.

The despair which followed the initial enthusiasm was slowly replaced by the next swing of the pendulum of experience, a long slow swing in which there was a gradual improvement in the manufacturing, mixing and use of the cements. Cements of higher purity were manufactured, the arsenic content being kept at a minimum. Protective varnishes were inserted between the tooth structure and the silicate cement. Precautions which must be observed in using the cement liquid were discovered. A better understanding of the limitations of their successful use developed.[3]

At the present time, it must be admitted that the silicate cements have earned for themselves a definite place in restorative dentistry. Brekhus and Armstrong[4] report that approximately 8 per cent of all fillings are of silicate cement. When one considers that this survey included both anterior and posterior teeth, it can easily be seen that a very large percentage of the fillings in anterior teeth are of silicate cement. The survey also shows that approximately 19 per cent of the silicate fillings have failed. The criteria by which success or failure of the silicate cement restorations was judged are not given in the report, but Dr. Brekhus, in a personal communication, says:

> . . . criteria used in determining failures in fillings were that, when fillings or tooth margins were so disintegrated that they ceased to preserve the tooth, they were adjudged failures. Contour, contact, color and other minor deficiencies were not taken into consideration.

TABLE 1.—MATERIALS INVESTIGATED

Trade Brand	Manufacturer	Address
Artificial Enamel	Ascher Gesellschaft	Berlin, Germany
Berylite	The W. V-B. Ames Co.	Fremont, Ohio
Certified Enamel	Lee S. Smith and Son Manufacturing Co.	Pittsburgh, Pa.
Crystone	Richter & Hoffman	Berlin, Germany
Durenamel*	Baker and Co., Inc.	Newark, N. J.
Enamodent—Anterior	Enamodent Laboratories, Inc.	Portland, Ore.
Enamodent—Posterior	Enamodent Laboratories, Inc.	Portland, Ore.
Filling Porcelain	The S. S. White Dental Manufacturing Co.	Philadelphia, Pa.
Kryptex	The S. S. White Dental Manufacturing Co.	Philadelphia, Pa.
Plastic Filling Porcelain	Baker and Co., Inc.	Newark, N. J.
Porsilon	Research Products Corporation	New York City
Synthay Porcelain	Garhart Dental Specialty Co.	Boston, Mass.
Synthetic Porcelain	The L. D. Caulk Co.	Milford, Del.

*Not made at the present time under this brand name.

MATERIALS INVESTIGATED

In order to make this investigation comprehensive, practically every dental

silicate cement which is widely used in the United States was investigated. The brand names of these cements, together with their respective manufacturers, are listed in Table 1.

Chemical Composition.—Chemical analyses of twelve silicate cement powders and liquids were made in order to (1) correlate composition and physical properties; (2) detect substances which might be harmful to pulp tissues, and (3) supply information useful to research workers and dental teachers.

Chemical Analyses of Powders: The methods of analysis were based upon those outlined by Hillebrand and Lundell.[6]

The results of the analyses of the cement powders, given in Table 2, show that these materials have a complex composition. (The order of listing bears no relation to the order of listing of the cements in Table 1.) Cement A is by far the simplest in composition and could probably be duplicated by fluxing the given amounts of silica, alumina and lime

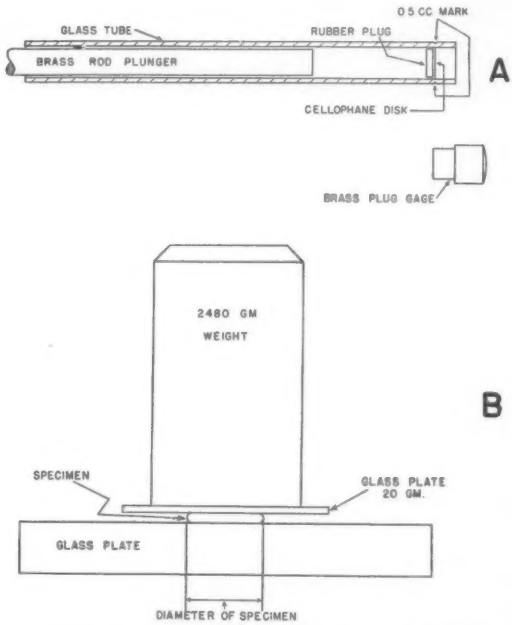


Fig. 2.—Apparatus used for determining consistency of unset plastic cement: A, glass tube used to measure volume of soft cement. B, weight and glass plates which flattened soft cement into disk. The diameter of this disk was used as a measure of the consistency of the cement mix.

Previous Work: Because of the difficulties inherent in a chemical analysis of silicate cements and because of the fact that their composition is a closely guarded trade secret, there is a paucity of literature on their composition. Matthews[5] reports the results of quantitative analyses on two silicate cements.

with sodium carbonate. The cements other than A have very complex compositions. This makes it difficult to calculate from the analyses the original ingredients used in compounding the powder.

Most of the constituents of all of the powders are very refractory materials. A

flux must therefore be used in order to fuse them into a glass or frit. The dental silicate cement powders may be roughly divided into classes, according to the type of flux used. One class, cements C, D, E, F, I, J, K and L, is evidently fused with the aid of fluxes containing fluorine. Another class, represented by cements A, B and H, is no doubt fluxed with sodium carbonate. In the case of cements B and H, beryllium salts may also have been used.

It will be noted that the calcium and sodium in some instances are reported as the oxides (Table 2, columns 3 and 6); in others, as the elements (Table 2, columns 4 and 7), because the analysis indicated that, in those cements containing fluorine, the calcium and sodium were present as fluorides and not as oxides.

It is interesting to note that six of the cements, A, D, I, K and L, have an alumina : silica ratio of approximately 0.7, and three cements, C, E and J, have an alumina : silica ratio ranging from 0.85 to 0.92. Contrary to some opinions, the relative proportions of alumina and silica evidently can be varied within rather wide limits. The most used cements in this country, which have in general the

TABLE 2.—COMPOSITION OF SILICATE CEMENT POWDERS (PERCENTAGE BY WEIGHT)

Column	1	2	3	4	5	6	7	8	9
Cement Powder	Silica (SiO_2)	Alumina (Al_2O_3)	Calcium Oxide (CaO)	Calcium (Ca)	Fluorine (F)	Sodium Oxide (Na_2O)	Sodium (Na)	Phosphorus Pentoxide (P_2O_5)	Loss on Ignition*
	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent °C.
A	47.2	33.1	10.4			8.7			0.7 (900)
B†	44.0	21.4	13.6			2.6		7.6	0.8 (120)
C‡	32.0	29.5		8.6	14.3		7.3	5.8	2.4 (850)
D	39.9	27.7		5.9	15.4		6.6	4.0	0.8 (110)
E#	35.1	29.9		7.9	14.2		7.3	5.4	0.1 (120)
F##	14.6	15.6		3.2	5.9		2.9	2.1	0.1 (120)
G	37.7	31.7		6.2	12.9		7.4	3.3	0.9 (900)
H§	29.7	23.1	5.8			7.6		24.0	2.7 (900)
I**	41.7	28.1		6.7	12.2		7.6	2.2	1.0 (900)
J	39.7	35.8		3.2	11.0		6.5	3.9	0.0 (110)
K	40.1	29.8		6.6	14.3		6.3	3.2	1.1 (900)
L††	36.5	26.3		5.9	12.0		4.6	3.2	6.9 (900)

*Ignition losses at 900°C. on those cements containing fluorides may be in error because of the volatilization of some silicon tetrafluoride (SiF_4).

†Contained 9.8 per cent of beryllium oxide (BeO) and 0.3 per cent of nickel oxide (NiO).

‡Contained 0.3 per cent of strontium (Sr).

#Contained 0.2 per cent of ferric oxide (Fe_2O_3).

##Contained 53.2 per cent of zinc oxide (ZnO); 2.3 per cent of magnesia (MgO), and 0.1 per cent of ferric oxide (Fe_2O_3).

§Contained 4.1 per cent of zinc oxide (ZnO); 2.9 per cent of beryllium oxide (BeO), and 0.2 per cent of magnesia (MgO).

**Contained 0.5 per cent of lithium oxide (Li_2O).

††Contained 9.4 per cent of zinc oxide (ZnO) and 0.5 per cent of magnesia (MgO).

Note: Analyses of powders A, D, E, F, H, I, J, K and L were made by the late Aaron Isaacs.

best physical properties, belong to the class which have been fused with fluorine-containing fluxes and which have an alumina : silica ratio of from 0.7 to 0.9.

Cement H has an unusual amount of phosphorus pentoxide, from almost three to twelve times that of the other phosphorus-containing cements. The unusual amount of phosphorus pentoxide appeared to have a very deleterious effect on the physical properties.

The powder of cement F contained over 53 per cent of zinc oxide, making the cement a hybrid between a dental silicate and dental zinc phosphate cement. A microscopic examination of the powder showed that the fusion was incomplete and that not every particle of cement powder F is the same in composition and in physical properties; nor is each particle one homogeneous mass, as the maker claims.

The powder of cement L is a mechanical mixture of silicate and zinc phosphate cement powders in the approximate ratio 9 to 1. Where a cement is desired which has some characteristics of both silicate and zinc phosphate types, this kind of mixture appears to have in general superior physical qualities.

All of the powders except A contained phosphorus pentoxide. It is thought that some phosphate, probably aluminum or calcium phosphate, is added to the powder as a retarding agent. The reaction between the powder and liquid of cement A proceeds too rapidly and would probably be retarded if a suitable amount of phosphate were added to the powder.

The presence of lithium oxide in cement I does not seem to enhance the properties.

Chemical Analyses of Liquids: Table 3 gives the composition of the liquids,

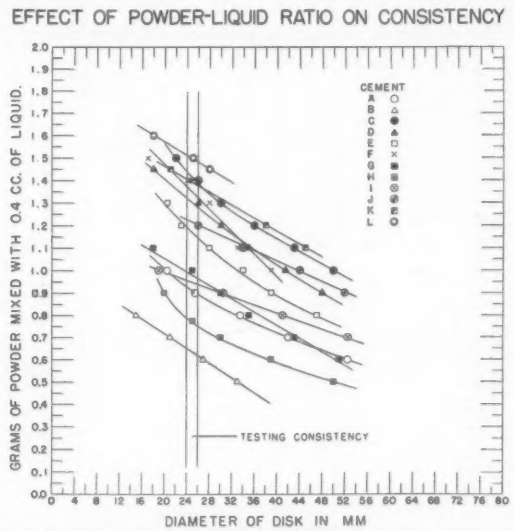


Fig. 3.—Diagram showing effect of powder-liquid ratio on consistency. The space between the two parallel perpendicular lines is labeled testing consistency because it represents the average consistency of the mix used by practicing dentists. To the left of the testing consistency space, the mixes are thicker than normal and to the right they are thinner. In the case of cement L, mixing 1.5 gm. of powder and 0.4 cc. of liquid produced a mix of standard testing consistency; whereas, in the case of cement B, incorporating only 0.65 gm. in 0.4 cc. produced the same consistency.

which are placed in the table in the same order as the powders in Table 4; *i.e.*, liquid A is the liquid supplied for use with cement A, etc.

The silicate cement liquids are aqueous solutions of phosphoric acid (H_3PO_4) partially neutralized by the addition of aluminum or of zinc salts, or both. They are very similar in composition to the zinc phosphate cement liquids,[7] but, in general, are higher in water and lower in acid content.

From the analyses, certain calculations (Table 3, columns 5, 6, 7 and 8) were made. Column 7, "total H_3PO_4," was derived from the experimentally determined phosphate content of the liquid (column 1), irrespective of whether it was present as phosphoric acid or as a salt of phosphoric acid. Column 6, "Combined H_3PO_4," indicates the quantity of phosphoric acid needed to react with the zinc, aluminum and magnesium content (columns 2, 3 and 4) to form the neutral phosphates. Column 5, "Free H_3PO_4," obtained by subtracting column 6 from column 7, indicates the total amount of uncombined phosphoric acid present. The percentage of water (column 8) was obtained by deducting the sum of Al, Mg, Zn and "Total H_3PO_4" (columns 2, 3, 4 and 7) from 100.

Cement liquids E and F are almost identical. The difference in their composition probably represents the differences of individual batches of the liquids. They are made by the same manufacturer to be used with cement powders E and F, respectively. An advertising booklet which describes cements E and F states that the liquids are distinct and different and cannot be interchanged; *i.e.*, liquid F cannot satisfactorily be used with powder E and vice versa. There appears to be no logical reason why they cannot be interchangeably used. The aforementioned booklet also states that each liquid contains a colloidal gelatinous catalytic agent, "hydrate of silicon dioxide," which "fixes the phosphoric acid by entering into reaction with the active silica-forming compounds which do not eliminate

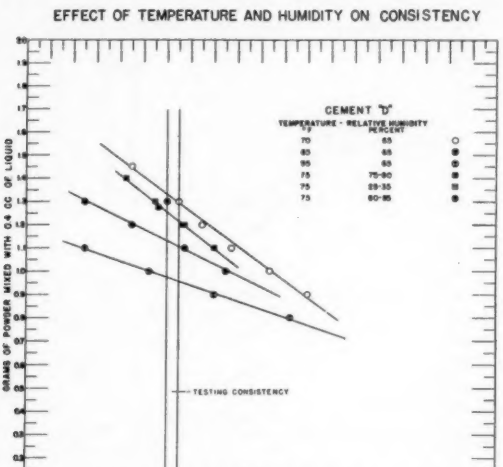

EFFECT OF TEMPERATURE AND HUMIDITY ON CONSISTENCY
CEMENT "D"
TEMPERATURE - RELATIVE HUMIDITY
PERCENT
GRAMS OF POWDER MIXED WITH 0.4 CC. OF LIQUID
TESTING CONSISTENCY
DIAMETER OF DISK IN MM

Fig. 3A.—Effect of temperature and humidity on consistency.

acid and exhibit a high stability in the presence of alkaline as well as acid mediums. In other words, the colloidal substance is used for the purpose of fixing any free surplus phosphoric acid that may result from any partial or incomplete combination of powder and liquid. This entirely new and unique process is the basis for the patents granted in the United States and other countries."

Silica was not chemically detected in cements, such as the degree of darkening, etc., spectrographic analyses were made by B. F. Scribner of the Spectroscopy Laboratory.

A survey of the compositions of the cements and their physical properties shows that the composition in itself is not sufficient to establish definitely the properties of a cement. For instance, two powders may have the same composition but be different physically. The composition, however, does bear a relation to the physical properties.

TABLE 3.—COMPOSITION OF SILICATE CEMENT LIQUIDS (PERCENTAGE BY WEIGHT)

Column	1	2	3	4	5	6	7	8
	Analyses				Calculations			
Cement Liquid	PO_4	Al	Zn	Mg	Free H_3PO_4	Combined H_3PO_4	Total H_3PO_4	Water*
	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
A†	60.1	1.9	7.7	—	47.6	14.5	62.1	28.3
B†	52.3	2.1	6.2	0.1	39.8	14.2	54.0	37.6
C‡	56.8	2.1	2.5	0.7	46.5	12.1	58.6	36.1
D†	47.4	2.3	5.6	—	35.0	13.8	48.8	43.3
E#	56.1	2.4	3.1	0.8	44.1	13.8	57.9	35.8
F#	55.7	2.4	3.1	0.7	43.6	13.9	57.5	36.3
G†	48.6	—	9.1	—	41.1	9.1	50.2	40.7
H† ##	51.9	3.3	—	—	41.7	11.8	53.5	43.2
I†	51.7	2.5	5.8		37.6	15.7	53.3	38.4
J†	48.6	—	8.9	—	41.3	8.9	50.2	40.9
K†	48.1	1.9	4.4	—	38.3	11.3	49.6	44.1
L†	48.1	1.9	4.4	—	38.3	11.3	49.6	44.1

*Water content calculated by difference.
†Contained less than 0.0002 per cent of arsenic.
‡Contained 0.0002 per cent of arsenic.
#Contained 0.0005 per cent of arsenic.
##Contained 0.3 per cent of calcium.
Note: Analyses of liquids K and L were made by the late Aaron Isaacs.

liquids E or F. Spectrographic analysis (Table 4) did show traces of silicon in both these liquids as well as in all of the liquids tested. This probably is a result of contamination from the glass container.

Spectrographic Analyses of Powders and Liquids: As an aid in the chemical analysis of the powders and liquids and in order to see whether there was any relation between impurities or traces of elements and certain properties of the

MIXING TECHNIC

Since these materials are to be compared, it is imperative that they be treated in an identical manner as far as possible. Therefore, a standardized procedure for mixing the cement (Fig. 1) and for forming the test specimens was developed. The mixing technic employed has the follow-

ing essential details: 1. The amount of powder to be used in 0.4 cc.* of liquid was determined by a consistency test hereinafter described. 2. The temperature of all materials and of the atmosphere in which the mix was made was 21° C. (70° F.). 3. The relative humidity of the atmosphere was maintained at 65 per cent. 4. The time of mixing was one minute. 5. A mass of powder representing about one-half of the total amount was drawn into the liquid and spatulated for fifteen seconds. Another portion, representing approximately one-fourth of the total amount, was incorporated in the following fifteen seconds. The remaining one-quarter portion was added and spatulated for thirty seconds (Fig. 1). 6. The mixes were made on glass slabs approximately 6 by 3 inches. Nearly one-half of the top surface of the slab was used in making the mix. 7. Every portion of the powder was thoroughly incorporated. No particles of powder nor unused liquid were allowed to remain around the edges of the mixed portion. 8. In mixing, a rotary motion in combination with a linear motion was used, with light pressure on the spatula. Intermittently, the cement was picked up and deposited in a heap and the process repeated. 9. All appliances were clean and free from particles of hardened cement.

The mixing technic just described is a very practical one and is entirely feasible for use in any dental office. Its chief difference from the usual technic now employed in dental practice is its preciseness, a necessary precaution in experimental work of this kind.

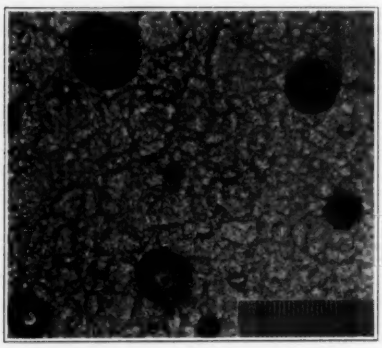


Fig. 4.—Photomicrograph of cement K, showing air bubbles, and powder particles embedded in a matrix of cementing substance. The appearance of the powder particles and the matrix indicates a very translucent cement, because their indices of refraction are near to each other. Each scale division is approximately 3.5 microns (0.00014 inch).

*The unit actually employed is the milliliter (ml.), the one thousandth part of a liter.

CONSISTENCY OF PLASTIC CEMENT MIX

It is common knowledge among the users of these cements that to produce mixes of the same consistency, the amount of powder for a given quantity of liquid must be varied with different cements. The method used in measuring the consistency of the zinc phosphate cements[8] was modified so as to make it suitable for determining the consistency of the silicate cements.

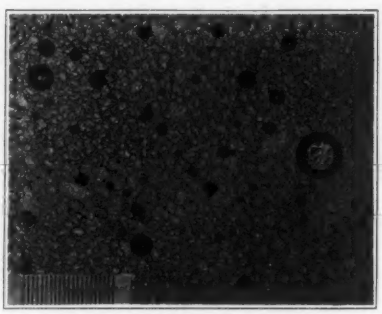


Fig. 5.—Photomicrograph of cement K (low magnification). The number of air bubbles are to be compared with the number in cement C in Figure 6. Each scale division is approximately 10 microns (0.0004 inch).

Apparatus.—A diagram of the apparatus used in determining the testing consistency is shown in Figure 2. This apparatus consists of (A) a glass tube

(inside diameter approximately 1 cm.) which will deliver a definite volume of mixed cement, and (B) two flat glass plates and a weight. The combined weight of the top plate and the weight is 2,500 gm.

additional weight (2,480 gm.) were carefully centered on the soft cement. The cement was thus pressed into a disk. The weight was removed ten minutes after the mixing was started. The average of the major and minor diameters of this

TABLE 4.—SPECTROCHEMICAL ANALYSIS OF SILICATE CEMENT POWDERS AND LIQUIDS

Cement Powders	Major Constituents	Minor Constituents and Traces*
A	Al, Ca, Na, Si	Ba, Cr, Fe, Ga, K, Li, Mg, Mn, Mo, Pb, Sr, U, V
B	Al, Be, Ca, Na, Ni, P, Si	Cr, Fe, Ga, K, Mg, Mn, Pb, Sr, Ti
C	Al, Ca, F, Na, P, Si, Sr	Cr, Fe, Ga, K, Mg, Mn, Pb, Ti, V
D	Al, Ca, F, Na, P, Si	Ba, Cr, Fe, Ga, K, Li, Mg, Pb, Sr, V
E	Al, Ca, F, Fe, Na, P, Si	B, Ba, Cr, Ga, K, Li, Mg, Mn, Mo, Pb, Sr, V
F	Al, Ca, F, Fe, Mg, Na, P, Si, Zn	Ba, Cr, Ga, K, Li, Mn, Pb, Sr, V
G	Al, Ca, F, Na, P, Pb, Si	Cr, Fe, Ga, K, Mg, Mn, Ni, Sr, Ti, V, Zn
H	Al, Be, Ca, Mg, Na, P, Si, Zn	Ba, Cr, Fe, Ga, K, Li, Mn, Mo, Pb, Sr, U, V
I	Al, Ca, F, Li, Na, P, Si	Ba, Cr, Fe, Ga, K, Mg, Mn, Pb, V
J	Al, Ca, F, Na, P, Si	Cr, Fe, Ga, K, Li, Mg, Ni, Pb, V
K	Al, Ca, F, Na, P, Si	Cr, Fe, Ga, K, Li, Mg, Pb, V
L	Al, Ca, F, Mg, Na, P, Si, Zn	Cr, Fe, Ga, K, Li, Pb, V
Cement Liquids	**Major Constituents**	**Minor Constituents and Traces***
A	Al, P, Zn	Ba, Ca, Cr, Fe, Ga, Mg, Pb, Si, Sr
B	Al, Ca, Mg, P, Zn	Fe, Si, Sr
C	Al, Mg, P, Zn	Ca, Fe, Pb, Si
D	Al, P, Zn	Ba, Ca, Fe, Ga, Mg, Pb, Si, Sr
E	Al, Mg, P, Zn	Ba, Ca, Fe, Ga, Ni, Pb, Si, Sr, V
F	Al, Mg, P, Zn	Ba, Ca, Fe, Ga, Ni, Pb, Si, Sr, V
G	P, Zn	Al, Ca, Cu, Fe, Mg, Pb, Si
H	Al, Ca, P	Fe, Mg, Pb, Si, Sr, Zn
I	Al, Li, P, Zn	Ca, Mg, Pb, Si
J	P, Zn	Al, Ca, Fe, Mg, Pb, Si, Sr
K	Al, P, Zn	Ca, Fe, Mg, Pb, Si
L	Al, P, An	Ca, Fe, Mg, Pb, Si

*These elements are present in amounts less than 0.1 per cent.

Method.—The desired amount of cement powder was mixed with 0.4 cc. of the cement liquid. Then 0.5 cc. of the mixed but unset cement was placed in the measuring tube and deposited on a flat glass plate. Two minutes after the mixing was started, another glass plate (weighing approximately 20 gm.) and the disk was considered a measure of the consistency of the cement mix.

It is well known that the physical properties of the silicate cements are changed by varying the powder : liquid ratio, and, in general, it may be said that the current cements of better quality are those in which a relatively large amount

of powder can be incorporated in a given quantity of liquid.

The relationship between the powder: liquid ratio and the consistency of the mix for each cement is shown in Figure 3. If all of the cements were mixed at the same powder: liquid ratio, some of the cement mixes would be too thin and others would be too thick. It was, therefore, necessary to mix all of the cements to the same consistency in order to make the physical data comparable.

The problem of selecting the proper consistency for use in preparing test specimens was solved by securing data from the manufacturers (Table 5, columns 1 and 2) and from the dental profession.

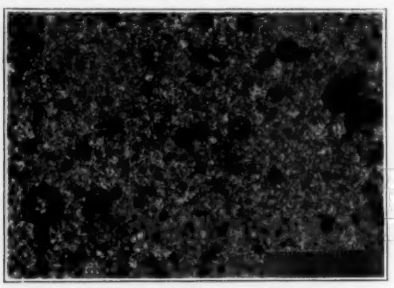


Fig. 6.—Photomicrograph of cement C at same magnification as cement K in Figure 5. The number of air bubbles are to be compared with the number in cement K in Figure 5. Each scale division is approximately 10 microns (0.0004 inch).

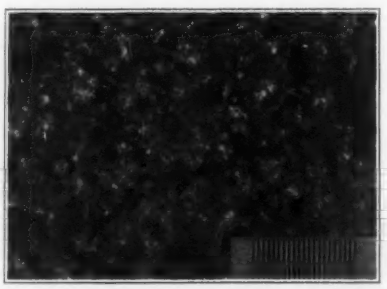


Fig. 7.—Photomicrograph of cement C, showing shrinkage cracks that develop when cement is not protected. Each scale division is approximately 10 microns (0.0004 inch).

In order to learn what consistency was being used in practice and in teaching, experiments were conducted by a selected group of practitioners and teachers who had done similar work with the zinc phosphate cements.[9]

The tabulation of the cooperators' data is shown in Table 5, columns 3, 4, 5 and 6.

The consistency finally selected as the standard testing consistency was one which gives a disk 25 ±1 mm. in diameter. This was based upon data secured from the profession and from our own test data. (Fig. 3.)

The amount of powder in grams which could be incorporated into 0.4 cc. of liquid at the standard testing consistency (25 ±1 mm.) is given for each cement in Table 5, column 7.

Influence of the Temperature and Humidity of the Mixing Environment.—The temperature and humidity conditions under which a dental silicate cement is mixed affect the properties of the cement, yet there appear to be few or no available data on the amount of change caused by these two factors.

To determine the magnitude of such changes, a cabinet within which the temperature and humidity could be controlled, was constructed. The essential exterior features of this cabinet are a glass top to permit observation of the experiments, and two arm holes fitted with rubber sleeves and gloves by means of which the experiments can be conducted in a closed system. A top view of the cabinet (Fig. 19) shows the general arrangements for the experiments. To maintain a constant humidity, a saturated aqueous solution of one of the following salts was used:

Salt	Relative Humidity
Potassium chloride (KCl)	80-85 per cent
Sodium chloride (NaCl)	75-80 per cent
Lithium chloride (LiCl)	25-35 per cent

If an excess of the undissolved salt is

present in the solution, a definite humidity will be maintained in the inclosed space. A table of various salts, together with the respective relative humidity values of the air above their saturated aqueous solutions, is given in the International Critical Tables.[10]

evaporation from the wet bulb was sufficient to change the humidity within the cabinet.

In order to determine the effect of temperature and humidity changes, the consistency of mixes of cement D was measured in controlled environments.

TABLE 5.—POWDER: LIQUID RATIOS

Manufacturers' Recommendations on Powder: Liquid Ratio			Cooperators' Results on Powder: Liquid Ratio Experiment				Standard Consistency	
	Amount of Powder in 0.5 cc. of Liquid	Amount of Powder in 0.4 cc. of Liquid*	Number of Mixes Reported	Amounts of Powder Used in 0.4 cc. of Liquid			Amounts of Powder Used in 0.4 cc. of Liquid††	Cement
Column	1	2	3	4	5	6	7	
Cement				Maximum	Minimum	Average		
	Grams	Grams		Grams	Grams	Grams	Grams	
A	1.26	1.01	20	1.57	0.98	1.21	0.90	A
B	1.01	.81					0.65	B
C		1.43†					1.45	C
D	2.00	1.60	20	1.75	0.91	1.32	1.30	D
E	1.80	1.44	15	1.50	1.12	1.32	1.15	E
F	1.30	1.04					1.30	F
G	0.9‡	1.20#					1.00	G
H##							0.80	H
I§							0.95	I
J	1.6–1.65	1.30	20	1.69	0.70	1.18	1.20	J
K	1.9	1.52	41	1.82	0.98	1.35	1.40	K
L##							1.50	L
M		1.50**					1.35	M

*Computed from 0.5-cc. values by multiplying by 0.8, with the exception of cement G.
†Value obtained from personal demonstration of representatives in laboratory.
‡Represents grams of powder in 0.3 cc. of liquid.
#Computed from 0.3-cc. value by multiplying by 1.33.
##No values given.
§Manufacturer did not reply to correspondence.
**Value computed from the 0.1-cc. value in the instruction sheet (which accompanied the packages) by multiplying by 4.
††Represents proportions of powder and liquid used in preparing test specimens in this report.

The relative humidity of the air within the cabinet was read directly on a hair hygrometer which was calibrated daily by comparing its readings with those of a rapid forced-ventilation wet-and-dry-bulb hygrometer. The use of a still-air wet-and-dry-bulb hygrometer within the cabinet was not satisfactory because the

Cement D was chosen for this series of experiments because its setting time was considerably affected by changes in the water content of its liquid (Table 17). In one series of experiments, mixes were made at a constant relative humidity of 65 per cent, but the temperature was varied. Measurements were made at

21° C. (70° F.), 28° C. (83° F.) and 35° C. (95° F.), respectively. The data on the consistency measurements (Fig. 3) show that, at the normal testing consistency for cement D, 1.3 gm. of powder could be incorporated in 0.4 cc. of liquid when the temperature was held at 21° C. (70° F.) and the relative humidity at 65 per cent. When the temperature was raised to slightly above 28° C. (83° F.) and the humidity held constant at 65 per cent, only 1.15 gm. of powder could be incorporated in 0.4 cc. of liquid. (Fig. 3A.) On raising the temperature to 35° C. (95° F.), slightly less than 1 gm. of powder could be incorporated in 0.4 cc. of liquid to produce a mix of normal testing consistency. The reduction in the amount of powder of cement D which could be incorporated in 0.4 cc. of liquid over a 14° C. (25° F.) range from 21° C. to 35° C. (70° F. to 95° F.) amounted to about 0.025 gm. per degree centigrade (0.014 gm. per degree Fahrenheit).

Reducing the powder:liquid ratio of a cement (K) mix increases solubility and disintegration and setting time and decreases compressive strength (Table 16). Such findings emphasize the importance of chilling the mixing slab to approximately 21° C. (70° F.) whenever the dew-point of the air is such that water will not condense upon the slab at this temperature. When this precaution is not taken, it is apparent that the resulting restoration will fail to give as satisfactory service as it should.

In another series of experiments, the temperature was held at 24°C. (75° F.) and the relative humidity was varied from 35 to 80 per cent. The data (Fig. 3A) show that the humidity variations produced a negligible effect on the powder: liquid ratio of cement D. The mixing in all cases was commenced immediately after placing the liquid on the slab. If the liquid were allowed to remain on the slab for several minutes prior to mixing, as is sometimes done in dental practice, the foregoing results would not hold because the liquid would change its water content as shown in Table 17, columns 4, 5 and 6.

There is one maxim that should never be forgotten when using silicate cements: "Always make the mix immediately after depositing the liquid on the slab." If this is done, serious unbalancing of the cement will be avoided.

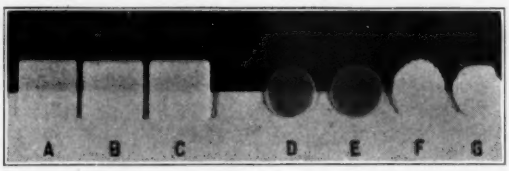


Fig. 8.—Glass standards and cement specimens having different opacities photographed on a black and white background. A, B and C alabaster glass standards are approximately 35, 50 and 55 per cent opaque respectively. D, cement K preserved in water. E, cement L, with 5 per cent of petrolatum, exposed to air. F, cement K with "Durosim," exposed to air. G, cement K, same as D, but exposed to air.

EFFECT OF BATCHES AND SHADES

It was anticipated at the beginning of this investigation that variances among batches of a cement would complicate the comparison of the different cements. Consequently, the original purchases of cements were generally large enough to last for the duration of the investigation. After taking this precaution, different batches were found in a few single purchase consignments. These different batches of the same cement were compared by noting the differences in their consistencies at a given powder: liquid ratio.

In the case of cement F, a definite difference was noted between the first and second purchases. In the first purchase, 1.3 gm. of powder in 0.4 cc. of liquid produced a disk having a diameter of 28.5 mm. In the second purchase, under the same test conditions, a much smaller disk was produced (14.5 mm. in diameter); which unquestionably demonstrates a difference between the products of this manufacturer when purchased at different times.

not have identical batch numbers, the differences may be due to the variation with batch and not with shade. The differences among batches of cements D and K are so small that they are of no practical concern and it is doubtful that a dentist could detect them in his routine use of the cements. However, differences such as were encountered in batches of cement F, for example, are large enough to be important. The disintegration, shrinkage and acidity of one batch (1.08 gm., 0.4 cc.) may be much greater than those of the other batch (1.30 gm., 0.4 cc.).

This simple consistency test is a desirable one for factory production control.

Table 6.—Effect of Humidity and Temperature on Initial Setting Time

Cement	Powder*	Setting Time	
		21°C. (70°F.)	37°C. (99°F.)
		65 Per Cent†	100 Per Cent†
1	2	3	4
	Grams	Minutes	Minutes
A	0.90	3.0	2.5
B	0.65	37.0	16.0
C	1.45	14.5	7.0
D	1.30	4.5	3.0
E	1.15	12.0	7.0
F	1.30	4.5	3.0
G	1.00	9.0	5.0
H	0.80	14.0	8.0
I	0.95	7.0	6.0
J	1.20	4.0	3.0
K	1.40	6.0	4.0
L	1.50	5.0	4.0
M	1.35	15.0	7.5

*Amount of powder necessary to mix with 0.4 cc. of liquid to make a disk 25 ± 1 mm. in diameter.
†Relative humidity.

Cement D (Shade 3) had a remarkable uniformity over a period of years. One batch, which is at least eighteen years old, since it was used in another investigation,[11] has approximately the same consistency for a given powder : liquid ratio as do comparatively recent batches.

Determinations of the consistency at one powder : liquid ratio of several shades of cements D and K showed them to be relatively uniform. Since the shades did

TIME OF SETTING

Importance.—The time of setting, or the interval of time between the mixing and the initial hardening of a cement, is one of its most important physical prop-

erties. Excessive retardation or acceleration of the setting time either renders the cement unfit for use or materially reduces its serviceability. If a cement hardens too rapidly, the amount of powder which can be mixed with a definite quantity of liquid to produce a standard consistency is reduced. When a fast-setting cement is used, there is not a sufficient interval of time for the dentist to insert the plastic cement properly in the cavity before the cement mix becomes so stiff that it cannot be manipulated properly. If the cement hardens too slowly, the operator and patient often become restless and the mixing, for inserting and for the adjustment of the matrix. However, in the manufacture and use of the silicate cements, the setting time cannot be controlled to such a definite value as five minutes and a tolerance must be permitted. A reasonable amount of variation would be a range of setting time from three minutes to eight minutes.

Method of Test.—In determining the setting time, every effort was made to make the conditions of the test like the conditions of use. A similar procedure was used in a former investigation.[7] When a standard Gillmore needle (weigh-

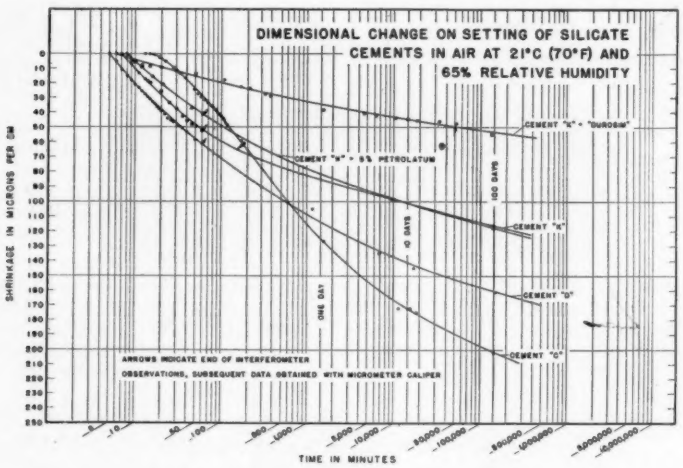

DIMENSIONAL CHANGE ON SETTING OF SILICATE CEMENTS IN AIR AT 21°C (70°F) AND 65% RELATIVE HUMIDITY
SHRINKAGE IN MICRONS PER CM
CEMENT "X" + "DURGUM"
CEMENT "W" + 5% PETROLATUM
100 DAYS
CEMENT "X"
10 DAYS
CEMENT "D"
ONE DAY
CEMENT "C"
ARROWS INDICATE END OF INTERFEROMETER OBSERVATIONS, SUBSEQUENT DATA OBTAINED WITH MICROMETER CALIPER
TIME IN MINUTES

Fig. 9.—Dimensional change on setting of silicate cements.

matrix is removed prematurely. Frequently, this produces a rough surface on the filling and breaks its contiguity. Sometimes, a slow-setting cement is allowed to come in contact with saliva before hardening; which produces a soft, opacified and porous surface on the filling and renders it comparatively worthless.

The setting time should therefore be controlled within narrow limits. Possibly a five-minute setting time is near to the ideal, as this will allow ample time for ing 1 pound) failed to make a perceptible circle on the surface of the cement, the initial setting was considered to be completed. When the cement is at this stage of hardening, the matrix may be safely removed and the cement should be given a protective coating. The setting times, which, in this report, are considered as the elapsed times between the beginning of the mixing and the instant when the Gillmore needle failed to make a circle on the surface of the cement, are given in Table 6. All cements except A and B

came within the probable ideal range, from three to eight minutes, when tested at 37° C. (99° F.).

Modifying Factors.—There are many factors in the time of setting. Some of these, for instance the composition of the powder and liquid and the fineness of the powder, are under the control of the manufacturer. Other conditions, such as the mixing procedure and care of the cement liquid, are under the control of the dentist.

The time of setting is (1) increased when the time of mixing is lengthened and when the powder : liquid ratio is reduced; (2) decreased with an increase in the temperature of the mixing slab, and (3) not appreciably affected by changing the rate of adding the powder. The consistency of the mix and the temperature at which the mixing is done seem to have the most pronounced effect on the setting time. Since this is so, it is felt that if the temperature of the glass slab used in making the mix is held between 18 and 24° C. (64 and 75° F.); *i.e.*, provided the dew-point will permit temperatures this low without precipitation of water upon the surface of the slab, if the time of mixing is one minute or less, and a stiff putty-like consistency is used, the principal difficulties in controlling the setting time will be eliminated.

TABLE 7.—COMPRESSIVE STRENGTH

Cement	Immersion Media						
	Distilled Water			Saliva		Oil	
	Age of Specimens						
	1 week	6 months	14 months	6 months	14 months	6 months	14 months
	1	2	3	4	5	6	7
	Lbs./In.²	Lbs./In.²	Lbs./In.²	Lbs./In.²	Lbs./In.²	Lbs./In.²	Lbs./In.²
A	19,500	25,000	23,000	26,000	23,500	30,000	34,000
B	10,500	15,500	14,000			22,000	20,500
C	18,500	22,500	17,000			27,500	28,500
D	19,500	22,500	24,000	24,000	24,500	29,000	28,500
E	19,000	20,500	19,500	23,000	22,000	29,500	32,000
F	19,500	20,500	18,000			29,000	32,000
G	14,000	17,500	14,000			20,500	21,000
H	12,000	12,500	10,500			15,000	19,000
I	20,000	22,500	19,000			30,500	31,000
J	21,500	21,000	19,500	24,000	25,000	23,500	24,500*
K	19,500	23,500	19,500	27,000	21,000	29,000	33,000
L	25,500	29,000	23,000			26,500	31,000

*Average of two specimens.
Note: To convert to Kg./Cm.², multiply values by 0.0703.

COMPRESSIVE STRENGTH

Even though the silicate cements are probably the strongest of all known dental cements, they are comparatively weak and brittle when compared with metallic substances. Their effective use is therefore largely confined to Class 3 cavities in the anterior teeth or to other simple and protected cavities. As a comparison, the compressive strength of the best sili-

cate cements is about one-half that of the high-grade amalgams, the weakest of the metallic materials used in restorative dentistry. A cement having a high strength, especially a high early strength, is a more desirable one provided the high strength is not developed at the expense of some other very important properties such as time of setting or insolubility. The strength of a cement should not lessen with time. In planning the experiments on compressive strength, the experimental work of Poetschke[12] was considered.

Preparation of Specimens.—Small cylinders about 6 mm. in diameter and 12 mm. long were formed by filling hard rubber molds with a standard mix of cement. A small glass plate was pressed against each end of the mold in order to

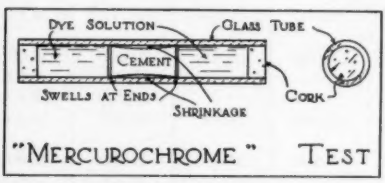


Fig. 10.—Mercurochrome test.

make the ends of the cylinders approximately plane and parallel. These (mold, plates and specimen) were then transferred to an environment having a temperature of 37° C. (99° F.) and a relative humidity of 100 per cent and left for one-half hour. The specimens and molds then were withdrawn and the ends of the specimens were made plane and parallel to within ±5 microns (±0.0002 inch) by drawing the mold containing the specimen across a glass plate charged with carborundum powder (No. 2F) and water.

Treatment of Specimens.—Specimens were stored in each of three liquids, namely, distilled water, saliva and oil. Distilled water was used because it is a standard and easily procured material and water is the chief constituent of saliva. However, as a control, it was thought best to immerse some specimens in natural saliva so that a comparison could be made between the strength of specimens immersed in water and those immersed in saliva. Five cements (A, D, E, J and K) were immersed in saliva. Oil (liquid petrolatum, U.S.P.) was also used because it is a neutral water-free medium and the strength of specimens immersed in it when compared with the strength of those immersed in water should give an indication of the effect of water on the strength of the cements.

All of the specimens were stored at 37° C. (99° F.). The water and the saliva, which was collected fresh each week and preserved with 0.1 per cent formalin solution, were changed weekly. The specimens were always submerged in the liquids except during testing, when they were kept moist with their respective liquid.

The specimens were tested and the data obtained in the same manner as with the zinc phosphate cements.[7]

Discussion of Data.—A comparison of the strengths of the six months old specimens in water, saliva and oil (Table 7, columns 2, 4 and 6) gives an indication of the relative effect of each liquid on the cements. All of the cements (six months old specimens) except cement L were strongest when immersed in oil and weakest when immersed in water. Those immersed in saliva were slightly stronger than those immersed in water.

The powder of cement L, which is a physical mixture of zinc phosphate cement powder and silicate cement powder in about the ratio of 1:9, is approximately 2,500 pounds to the square inch stronger in water than in oil. This same relation was observed when cement L was tested at a thinner consistency in the zinc phosphate cement investigation.[8]

The decrease in strength of silicate cements stored in water over those stored in oil was anticipated because the cements are somewhat soluble in water (Table 8).

Since the values for the specimens immersed in saliva and water are so near to each other, it is believed that distilled water is a satisfactory medium for storing specimens which are to be used in laboratory tests.

A comparison of the strengths of the fourteen months old specimens in water, saliva, and oil (columns 3, 5, and 7, Table 7) shows that the oil-immersed specimens are the strongest.

It is also interesting to observe the increase or decrease in strength from the six to the fourteen months old specimens. In the case of the oil-immersed specimens (columns 6 and 7, Table 7), there is an increase in strength in all of the cements except B and D. In the water-immersed specimens, there is a decrease in strength from the six to fourteen months old specimens (columns 2 and 3, Table 7) in all of the cements except D. In saliva, of the five cements tested, D and J show slight increases in strength, whereas A, E and K show decreases. (Table 7, columns 4 and 5.)

Attention is directed to the fact that cement D has the lowest solubility of all of the cements (Table 8). This assists in explaining why cement D is stronger after fourteen months' immersion in water than after six months' immersion. The same behavior is observed with cement D in saliva.

The values in column 1, Table 7 show the compressive strengths after the specimens were immersed in water for one week. These data were secured in order that a comparison might be made between the strengths after short and long periods of immersion in water. This comparison is essential because, in routine laboratory tests, it is necessary that the test period be reasonably short, but, at the same time, be indicative of the behavior of the cement over a much longer time period.

The strengths of all the cements in-

TABLE 8.—SOLUBILITY AND DISINTEGRATION OF SILICATE CEMENTS IN DISTILLED WATER*

Cement	Time in Water at 37° C. (99° F.)					
	1 Week	2 Weeks	3 Weeks	4 Weeks	5 Weeks	Total Loss
	Percentage Loss in Weight					
	1	2	3	4	5	6
A	3.0	0.6	0.4	0.4	0.3	4.7
B	3.5	0.6	0.4	0.4	0.3	5.2
C	1.9	0.5	0.3	0.3	0.2	3.2
D	0.6	0.2	0.1	0.1	0.1	1.1
E	2.4	0.3	0.2	0.2	0.1	3.2
F†	0.2	0.1				
G	2.7	0.7	0.5	0.5	0.3	4.7
H	5.0	1.3	0.8	0.6	0.6	8.3
I	1.5	0.3	0.2	0.2	0.2	2.4
J	2.8‡	0.5	0.3	0.3	0.2	4.1
K	1.3	0.4	0.3	0.3	0.2	2.5
L	2.0	0.3	0.1	0.1	0.1	2.6
N#	0.13	0.07	0.06			

*Specimens were disks 2 mm. thick and 20 mm. in diameter.
†Not a true silicate cement. (See Table 2.)
‡Other values on different batches ranged from 1.5 to 0.9 per cent.
#Zinc phosphate cement.

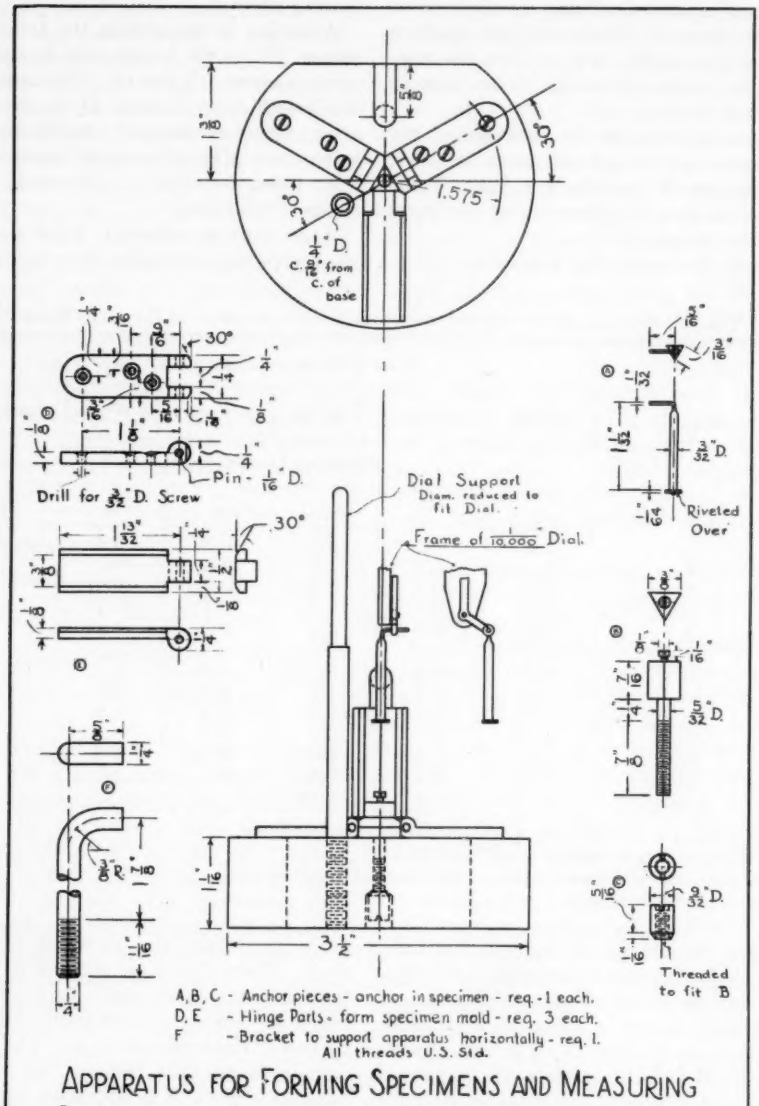

1.575
30°
30°
1/4" D.
c. 3/16" from c. of base
Drill for 3/32" D. Screw
Pin - 1/16" D.
Dial Support
Diam. reduced to fit Dial.
Frame of 1/10,000" Dial.
Riveted Over
3/32" D.
Threaded to fit B
3 1/2"
A, B, C - Anchor pieces - anchor in specimen - req. - 1 each.
D, E - Hinge Parts - form specimen mold - req. 3 each.
F - Bracket to support apparatus horizontally - req. 1.
All threads U.S. Std.
APPARATUS FOR FORMING SPECIMENS AND MEASURING DIMENSIONAL CHANGE ON SETTING OF SILICATE CEMENT

Fig. 11.—Apparatus for forming specimens and measuring dimensional change on setting of silicate cement.

crease from one week to six months in water (Table 7, columns 1 and 2) with the exception of cement J, and the difference in strengths in this case is too small to be of any importance. The strengths of cements C, F, H, I, J and L are less after fourteen months' immersion in water than they are after one week's immersion, and it is believed that, for all practical purposes, the strength at one week is not far removed in most instances from the strength at fourteen months

TABLE 9.—pH VALUES OF POWDERS AND LIQUIDS

Cement	Powder*	Liquid†
	pH	pH
A	7.6	2.1
B	7.5	2.3
C	7.6	1.9
D	7.6	2.3
E	7.6	2.1
F	7.6	2.1
G	7.6	2.1
H	5.3	2.0
I	7.6	2.1
J	7.5	2.1
K	7.6	2.2
L	7.6	2.1

*One gram of powder in 25 cc. of distilled water.
†0.4 cc. of liquid in 25 cc. of distilled water.

when the specimens are immersed in distilled water.

Cement H, which has the highest solubility of all of the cements (Table 8), has also the lowest compressive strengths for specimens six and fourteen months old. This cement is approximately 14 per cent stronger at the end of one week than it is at fourteen months.

Increase in Strength with Time.—Specimens of cement D were prepared, stored in distilled water at 37° C. (99° F.) and crushed at different time intervals, ranging from fifteen minutes to fourteen months. In fifteen minutes, the strength reaches approximately 40 per cent. In three hours, it reaches approximately 60 per cent of the strength at fourteen months.

SOLUBILITY AND DISINTEGRATION

Although silicate cement is widely used because of its toothlike appearance and its ease of manipulation, most dentists consider it as a temporary filling material because of its tendency to dissolve and disintegrate in the mouth. In most dental practices, silicate cement has replaced gold foil to a great degree. Black[13] believes that the average life of a silicate filling is probably less than two years and that, during much of this period, the contact point is not maintained and decay is likely to recur. Conzett and Means, in a discussion of Black's paper, heartily agree with his ideas on the limitations of silicate cement as a filling material.

To obtain other opinions on the life expectancy of silicate fillings, an inquiry was sent to about fifty dentists who practice in various sections of the country, asking them to estimate the probable life of the silicate cement fillings in their practices. The estimates usually ranged between three and five years. Many exceptions were noted. In the mouths of certain patients, the silicate cement fillings would not give more than six months of satisfactory service; whereas, in the mouths of other patients, the fillings would be satisfactory for as long as twelve years. Some of the cooperating dentists observed that if the silicate cement filling is in contact with the gum tissue (such as in a Class V restoration where a portion of the filling is beneath the free margin of the gum), its life will be materially shortened. It does seem to be generally observed that the length of satisfactory service which a silicate cement filling will give is subject to the oral environment

and to the location of the restoration. There is a possibility of a relationship between the susceptibility or immunity of an individual to caries and durability of silicate cement fillings in his mouth. Such a correlation can be established only by the practitioner. In fact, accurate observation and records of the actual behavior of silicate cements in the mouth are sorely needed.

Previous Work.—Voelker,[14] in 1916, published data on the solubility of powdered silicate cement in distilled water and in an aqueous solution of lactic acid. His value for the same brand of cement with sodium tartrate, is very interesting. He found that in fruit juices, wines and sour milk, the pieces of enamel were more resistant to disintegration than the silicate cements. He reported little or no loss in weight in distilled water. In tests conducted by Matthews,[5] pellets were immersed in distilled water for seven days, after which the percentage loss in weight was calculated.

Method of Test.—The tests for solubility and disintegration in this report are very similar to those specified in the American Dental Association Specification No. 8 for Dental Cementing Me-

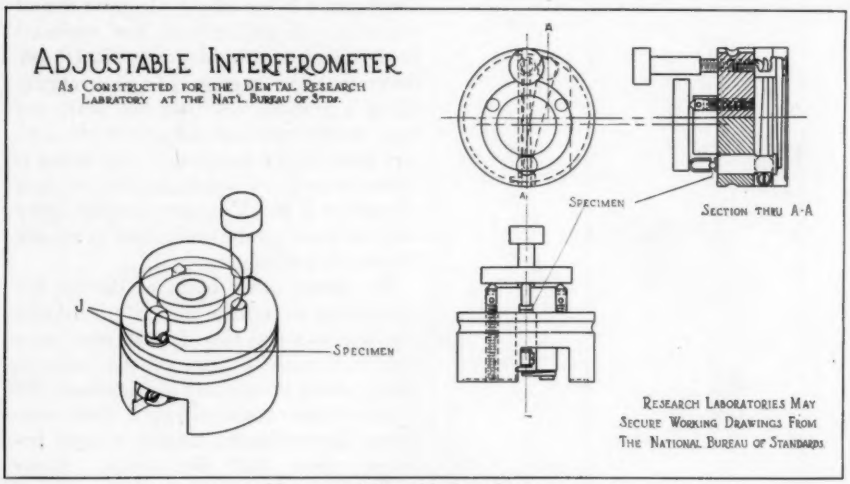


Fig. 12.—Adjustable interferometer.

is approximately three times as much as the values reported in this paper. Rosthj's[15] solubility tests using pyramidal specimens, in a 2 per cent aqueous solution of acetic acid and a 2 per cent aqueous solution of lactic acid, showed that the silicate cements appeared to be much more soluble in lactic than in acetic acid. Naeslund's[16] extensive work on the comparative solubility of pieces of enamel and dental cements in a large series of solutions, including distilled water, saliva, fruit juices and wines, sour milk, organic acids and solutions of citric acid buffered dium.[8] The tests were repeated each week for five weeks and then discontinued because the losses in weight were becoming too small to be accurately determined under the test conditions and were also becoming constant. All tests were run in duplicate.

Discussion of Data.—The loss in weight at the end of the first week (Table 8) is large when compared to the losses during the subsequent four weeks; which indicates the presence of some soluble constituent that is largely leached out during the first week. In Table 8, col-

umn 6, the total loss for the duration of the tests is given. The maximum loss (8.3 per cent) occurred on cement H, which contained an unusually large amount of phosphate (Table 2).

The loss in weight of cement D at the end of the first week was relatively very small, being from about one-half to one-eighth that of the other cements. This test was repeated four times, and on each test the loss in weight at the end of the first week was between 0.6 and 0.7 per cent.

Cements A, B and H do not contain fluorine and had the highest initial weight losses; which makes it appear that the presence of fluorine tended to reduce the solubility and disintegration.

The powder of cement F contains over 50 per cent of zinc oxide and cannot be classed as a true silicate cement. Cement N is a zinc phosphate cement which, like cement F, has a very low solubility and disintegration in distilled water.

The comparative solubility and disintegration of silicate and zinc phosphate cements as shown by these tests appear to be out of harmony with the usual clinical observations. It must be remembered, however, that durability depends on initial solubility, total solubility, relative hardness, resistance to hydrogen sulfide and other conditions, and not alone on the initial solubility and disintegration.

There was no significant difference in the solubility and disintegration of polished and unpolished disks.

Cement D, when powdered, was about four times as soluble as the disk. The solubility of powdered enamel prepared from clean extracted teeth which were dried overnight in an oven at 60° C. (140° F.) was 0.8 per cent. The enamel was cleaved from the dentin by tapping with a hammer.

When 3 grams of cement powder A was digested in 100 cc. of water, for one hour on a steam bath, only 0.4 per cent loss in weight was noted. Obviously, this does not explain the 3.0 per cent loss on cement A.

TABLE 10.—CHANGE OF pH OF SILICATE CEMENTS WITH TIME*

Cements	Powder	pH Value at						
	Grams†	15 Minutes pH	20 Minutes pH	1 Hour pH	2 Hours pH	4 Hours pH	6 Hours pH	24 Hours pH
A	0.90	3.5	3.9	4.4	4.7	4.9	5.3	5.5
D	1.30	3.6	5.0	5.5	5.4	5.5	5.6	5.8
H	0.80	2.8	3.3	3.9	4.2	4.5	4.8	4.8
J	1.20	3.7	4.6	4.7	4.6	4.8	4.9	5.6

*Age of specimen calculated from the beginning of the mixing.
†Grams of powder mixed with 0.4 cc. of liquid to produce a mix of standard consistency.
Note: The distilled water used as the solvent had a pH of 5.6-6.0.

pH MEASUREMENTS

Previous Work.—One of the principal theories used to explain pulp irritation under silicate cement restorations has been based upon the acidity of these cements. The adherents to this theory claim that the acid substances released by the cement continually irritate the pulp and act as a protoplasmic poison. As early as 1907, experiments[17] on the acidity of silicate cements were published. Crowell[18] made an extensive and careful

study of the acidity and alkalinity of dental cements by the colorimetric method and reported that, after seven days, the leachings of three different brands of silicate cement had pH values of 5.6, 5.8 and 5.5.

Method.—The values herein reported were determined electrometrically. The degree of acidity or alkalinity (pH value) of the cement powders, cement liquids and hardened and partially hardened cement were determined by the following methods. All measurements were made at 25° C. (77° F.) on (1) solutions prepared by mixing 1 gm. of a dental silicate powder with 25 cc. of distilled water; (2) solutions prepared by adding 0.4 cc. of a dental silicate cement liquid to 25 cc. of distilled water, and (3) solutions prepared by immersing disks of hardened cements in 25 cc. of distilled water.

It is recognized that the pH values obtained by the foregoing procedure do not represent the actual pH values of silicate cement powders and liquids nor the pH of any isolated portion of the set cement. It was necessary, however, to adopt some standard procedure whereby the values could be compared. Furthermore, in the case of the cement powders and set cement samples, direct pH measurement without the addition of a suitable solvent was impossible.

Discussion of Tests and Data.—The pH values of twelve silicate cement powders and liquids are given in Table 9. With one exception, all of the powders were slightly alkaline (pH 7.5-7.6). The exception, the powder of cement H, was definitely acid (pH 5.3). This cement powder is known to have an unusually large phosphate content. (Table 2.) The liquids are very acid and all are of about the same degree of acidity (pH 1.9-2.3). The liquid of cement C, the most acid of all, was advertised as consisting of almost completely neutralized phosphoric acid.

In the experiments in which information on the pH of hardened and partially hardened cements was to be obtained, the procedure was of necessity somewhat more elaborate. Information on the

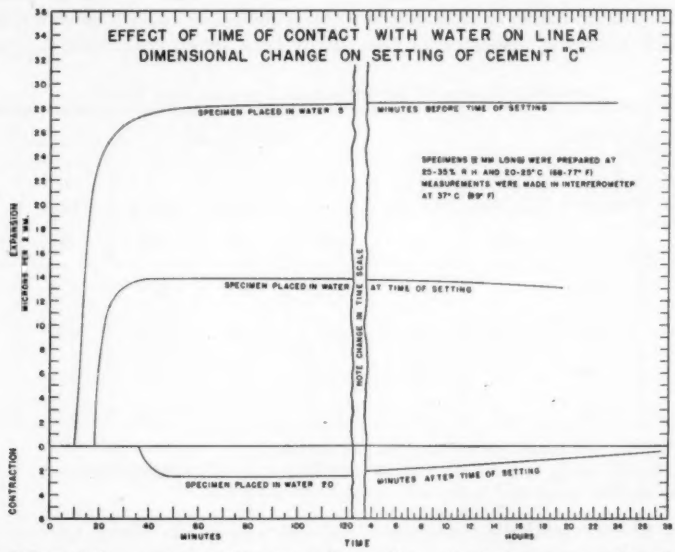

EFFECT OF TIME OF CONTACT WITH WATER ON LINEAR DIMENSIONAL CHANGE ON SETTING OF CEMENT "C"
SPECIMEN PLACED IN WATER 5
MINUTES BEFORE TIME OF SETTING
SPECIMENS 12 MM LONG WERE PREPARED AT 25-35% R H AND 20-25° C (68-77° F)
MEASUREMENTS WERE MADE IN INTERFEROMETER AT 37° C (99° F)
SPECIMEN PLACED IN WATER
AT TIME OF SETTING
NOTE CHANGE IN TIME SCALE
SPECIMEN PLACED IN WATER 20
MINUTES AFTER TIME OF SETTING
EXPANSION
CONTRACTION
MINUTES
HOURS
TIME

Fig. 13.—Effect of time contact with water on linear dimensional change on setting of cement C.

acidity of the plastic cement at the time it is normally placed in the cavity, as well as the acidity after various periods of time have elapsed, during which the cement changes from a plastic mass to a hard set cement, was desired. To obtain these data, mixes of the cement were made and the mixes immediately immersed in distilled water at approximately the time the dentist would introduce it into the tooth cavity. Other mixes made in the same manner were pressed into thin disks of a definite diameter (20 mm.) between two glass plates, and were permitted to harden in the air of a closed container containing water maintained at a temperature of 37° C. (99° F.) for periods of fifteen minutes, thirty minutes, one hour, two hours, four hours, six hours, and twenty-four hours before being placed in the distilled water.

The data on four cements, representing four different types, cement D, which contained fluorides, cement A, which did not contain fluorides, cement J, which was high in alumina, and cement H, which was high in phosphorus, are given in Table 10.

At the end of fifteen minutes, the cement solution is decidedly acid and, with time, the acidity slowly decreases until, at the end of twenty-four hours, most of the cements are approaching neutrality. This means that when the plastic cement is first introduced into the cavity, its acidity is relatively high, and it is probably at this time that the greatest injury to the pulp is liable to occur. This is especially true if the dentin has been drastically dried and so has rapidly absorbed some of the liquid portion of the very acid unset cement. The need of varnishing the cavity floor and walls to prevent or retard the penetration of such acid substances toward the pulp is self-evident. At the end of twenty-four hours, the pH values of most of the cement solutions (5.6-6.0) were equal to the pH values of the distilled water used in all of the experiments. The distilled water used in obtaining the solutions for the pH determinations was not at the theoretical neutral point (pH 7.0), but was slightly acid in reaction because of dissolved carbon dioxide.

Many conclusions about the persistent acidity of silicate cements are probably based upon data of pH measurements of solutions of the cements in acid-reacting distilled water, and therefore are possibly erroneous. There are no doubt exceptions to the foregoing statements. Cement H

TABLE 11.—OPACITY OF SILICATE CEMENTS

1	2	3	4
		Opacity at	
Cement	Shade	1 Week $C_{0.70}$ *	7 Months $C_{0.70}$ *
A	4	0.75	0.64
B	3 c	0.78	
C	2	0.53	0.57
D	3	0.46	0.40
E	9	0.60	0.54
F	3	0.97	1.00
G	3	0.62	0.54
H	4	0.65	0.57
I	9	0.41	0.35
J	1	0.32	0.28
K	3	0.25	0.23
L	3	0.73	0.62

*The $C_{0.70}$ value represents the daylight apparent reflectance (R_0) of the cement specimen (1 mm. in thickness) when placed over a black glass backing divided by the daylight apparent reflectance ($R_{0.70}$) of the cement specimen when placed against a white backing with an apparent daylight reflectance relative to MgO of 70 per cent. When the reflectances are the same, the $C_{0.70}$ value is 1.00 and the cement is 100 per cent opaque. If $C_{0.70}$ is equal to 0.50, the cement is said to be 50 per cent opaque, etc.

seems to be such an exception. Its initial acidity was high (pH 2.8). At the end of six hours, it had reached pH 4.8, and when the specimen was twenty-four hours old, the acidity was still at pH 4.8; which indicated that equilibrium conditions were being approached more slowly than in the other cements. The cement might remain acid in reaction indefinitely.

THE INDICES OF REFRACTION

The translucency of silicate cements is one of their unique and most valuable attributes. Since the translucency of a heterogeneous material is dependent in part on index of refraction, some determinations on this property were made.

A mix of dental cement consists of particles of powder (which are not entirely dissolved by the action of the liquid) bound together by the cementing substance or matrix. (Fig. 4.) In silicate cements, both the powder particles and the matrix are isotropic; *i.e.*, the particles transmit light at a constant speed in all directions. If the powder particles and the matrix had the same index of refraction; *i.e.*, if a ray of light on striking their surfaces at an oblique angle would be deflected a like amount in each, the cements would be transparent, like window glass. Also the greater the difference between the indices of refraction of the powder particles and the matrix, the more impervious to light would the cement become, until it would be completely opaque. The particle size of the powder will influence these phenomena to a slight extent.

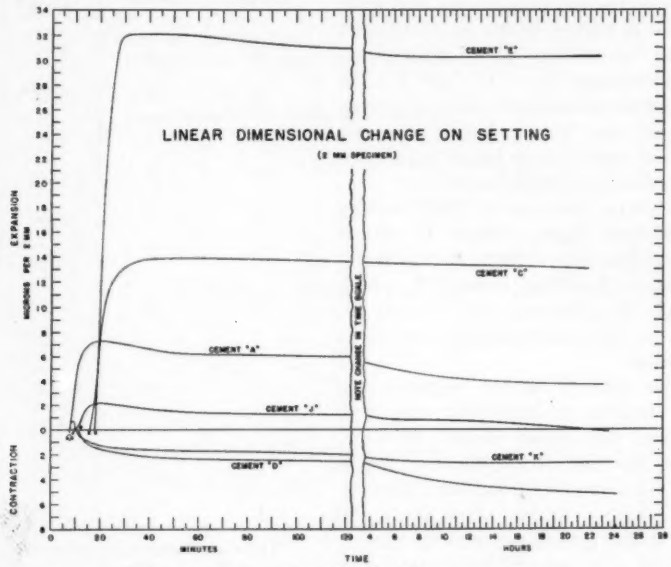


Fig. 14.—Linear dimensional change on setting.

In the zinc phosphate cements, the index of refraction of the particles of zinc oxide is much higher than that of the matrix; which makes these cements much more opaque than the silicates. The silicate cements F, H and L all contain some zinc oxide (Table 2), which materially increases opacity, the degree depending on the amount present. (Table 11.)

The indices of refraction of the particles of powder of the cements other than F, H and L ranged from about 1.47 to 1.60. In some cases, the particles were

TABLE 12.—OPACITY OF HUMAN TEETH

Specimen	Tooth*	Plane of Section	Opacity	
			Enamel†	Dentin†
			$C_{0.70}$	$C_{0.70}$
12	Upper central incisor	Mesiodistal	0.46	0.83
14	Upper central incisor	Mesiodistal	0.30	0.68
16	Upper central incisor	Mesiodistal	0.51	0.91
15	Upper central incisor	Labiolingual	0.67	0.76
13	Upper central incisor	Labiolingual	0.54	0.67
10	Upper lateral incisor	Mesiodistal	0.34	0.69
11	Upper lateral incisor	Mesiodistal	0.41	0.77
8	Upper cuspid	Mesiodistal	0.40	0.65
9	Upper cuspid	Mesiodistal	0.29	0.86
2	Upper cuspid	Labiolingual	0.39	0.50
2	Upper cuspid	Labiolingual	0.41	0.63
7	Upper cuspid	Labiolingual	0.35	0.67
6 A	Upper first bicuspid	Buccolingual	0.21	0.60
4	Upper first molar	Mesiodistal	0.40	0.74
4	Upper first molar	Mesiodistal	0.28	0.93
4	Upper first molar	Mesiodistal	0.37	
4	Upper first molar	Mesiodistal	0.38	
3 A	Lower central incisor	Labiolingual	0.31	0.55
4 A	Lower central incisor	Mesiodistal	0.38	0.69
5 A	Lower lateral incisor	Labiolingual	0.25	0.70
2 A	Lower cuspid	Buccolingual	0.34	0.63
1 A	Lower first bicuspid	Buccolingual	0.40	0.73
1	Lower first molar	Mesiodistal	0.44	0.78
1	Lower first molar	Mesiodistal	0.55	0.51
5	Lower second molar	Mesiodistal	0.41	0.53
5	Lower second molar	Mesiodistal	0.42	0.87
5	Lower second molar	Mesiodistal		0.63
5	Lower second molar	Mesiodistal		0.75
3	Enamel cut at right angles to long axis of rods		0.42	
6	Enamel cut at right angles to long axis of rods		0.32	
		Average values	0.39	0.70

*Some of these sections were prepared by Paul C. Kitchin, College of Dentistry, Ohio State University.

†Data calculated for specimens 1 mm. in thickness.

homogenous; in others, they contained clouds of minute crystals, usually of a considerably lower index than that of the main body of the particle. The indices of the cementing substance or the matrix varied from 1.45 to 1.48. As a specific example, the powder of cement K has an index of refraction of about 1.48 and the matrix of cement K has an index of approximately 1.46, with the result that this were also measured. Dentin from a vital upper central incisor had a mean index of about 1.56 ± 0.005; whereas dentin from a pulpless upper central incisor was just measurably lower than 1.56. Human enamel from vital and pulpless upper central incisor teeth had a mean index of refraction of about 1.60. In 1930, Cape and Kitchin[19] reported values of 1.56 and 1.62 for dentin and enamel, respectively.

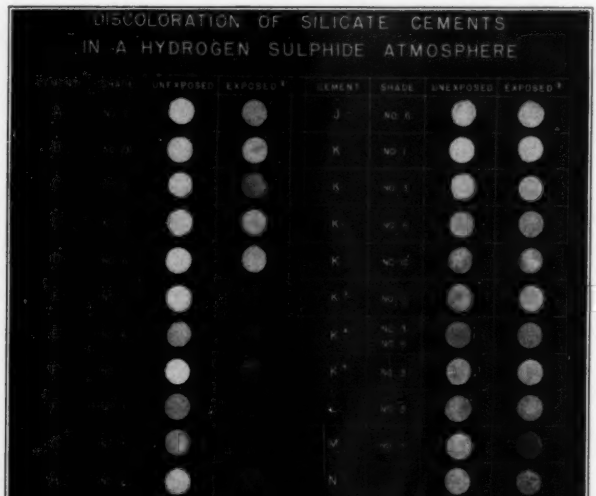


Fig. 15.—Discoloration of silicate cements in hydrogen sulfide atmosphere.

is a comparatively translucent cement (Fig. 8) (Table 11). The powder of cement A has an index of approximately 1.54 and the matrix an index of 1.48. Here, the difference between the indices is relatively large and therefore cement A is much less translucent than cement K (Table 11).

The refractive indices of tooth tissues Thus, it is seen that silicate cements have lower mean refractive indices than human tooth tissues. Undoubtedly, a better appearance would be obtained if the index of the cements could be raised to possibly 1.54, but, as Crowell[18] has pointed out, the index of refraction of the cement matrix cannot be varied greatly, and one of the most difficult problems in making a

silicate cement is to obtain a powder with an index not too far removed from that of the matrix.

Since opacity of a silicate cement restoration in the mouth is not a simple result of the variation in indices of refraction of the components of the cement, it was found necessary to resort to a more direct method of determining opacity.

The petrographic examination and photomicrographs were made by H. Insley of the National Bureau of Standards. The indices of refraction were determined by the Becke method. The photomicrographs were made by transmitted light.

TABLE 13.—EFFECT OF SIZE AND SHAPE OF SPECIMEN ON DIMENSIONAL CHANGE ON SETTING*

Cement	Length of Specimen		
	2 mm.†	10 mm.‡	25 mm.#
	Linear Change at End of 24 Hours		
	Per Cent	Per Cent	Per Cent
A	+0.18	−0.04	−0.03
C	+0.66	−0.10	−0.08
D	−0.25	−0.23	−0.24
E	+1.52	———	−0.21
J	−0.005	−0.16	−0.13
K	−0.14	−0.17	−0.25

*All specimens were immersed in water at the time of setting.

†Specimens were small cylinders about 2 mm. (0.08 inch) in diameter and 5 mm. (0.2 inch) long. Measurements were made parallel with the diameter.

‡Specimens were small cylinders about 5 mm. (0.2 inch) in diameter and 10 mm. (0.4 inch) long. The top surface of the cylinder was conical. Measurements were made parallel with the axis.

#Specimens were triangular in cross-section. Each side of the triangle was approximately 10 mm. (0.4 inch) long. The length of the specimens was approximately 25 mm. (1 inch). Measurements were made on the 25-mm. dimension.

MICROSTRUCTURE

In the mixing of a silicate cement, a certain amount of air is unavoidably incorporated in the mix. Part of this air is present in the powder and part is probably introduced during spatulation. Figure 5, a photomicrograph of cement K, shows many circular areas, which are air bubbles. These air bubbles make the cement less translucent because the index of refraction of air is 1.00; whereas the mean index of refraction of this silicate cement is about 1.46. The air bubbles also make the cement porous. They cannot be conveniently eliminated, as they would be if mixed in a vacuum, but they can be reduced by the use of a mixing technic in which beating or folding motions of the spatula are eliminated as much as possible. When Figure 6, a photomicrograph of cement C, is compared with that of cement K (Fig. 5), it will be noted that there appears to be less air in cement K than in cement C. It is believed that the relative viscosities of the two liquids may account for this. A glance at Table 3 shows that cement liquid K has more water and less phosphoric acid than cement liquid C, and that, therefore, cement liquid K is less viscous than cement liquid C.

Figure 4, a photograph of cement K at a higher magnification than Figure 5, shows how the powder particles, which are not completely dissolved by the liquid, are bound together by the matrix. The individual grains of powder are rather difficult to see because the indices of refraction of the grains of powder and of the matrix are fairly close together. It is estimated that the matrix amounts to roughly from 20 to 30 per cent of the hardened cement. This is equivalent to saying that from 70 to 80 per cent of hardened cement K consists of the original powder particles. Only the surface of the particles is attacked by the liquid to form the reaction products which make up the matrix or cementing substance.

These photomicrographic specimens were made by pressing a mix of cement into a thin film between two microscope cover glasses. If the edges of the cover glasses were not sealed or placed under water, the cements soon lost water and began to shrink and crack. Some of the cements did this more rapidly than others. Figure 7, a photomicrograph of cement C, shows the cracks which developed when the cement was not immersed in water after hardening. This cement, according to some of the advertising statements extolling its advantages, "does not check, crack, or become chalky, either when wet or dry." Such cracks are evidence of great shrinkage, and cements therefore must always be covered with saliva or water after the initial hardening.

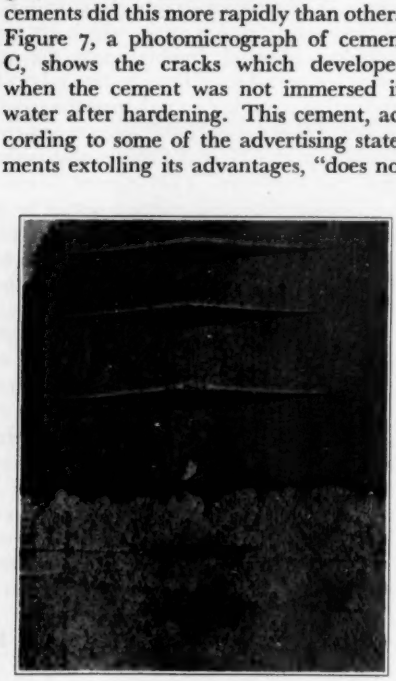


Fig. 16.—Indentation marks made in very highly polished enamel from the buccal surface of a lower first molar. The enamel rods are not fully in transverse section. The indentation hardness marks are near the dentino-enamel junction. (Transverse section of crown of lower first molar.) The long marks are in dentin; the short marks, in enamel. The enamel fractured around the marks because of the condition of the enamel surface. It is difficult to polish dentin and enamel at the same time because of their difference in hardness.

OPACITY

Definition.—The common conception of an opaque material is a material which does not transmit light. In photometry, however, the term opacity is used to designate different degrees of transmission of light. One material may be 100 per cent opaque, another 70 per cent opaque, etc. The words, translucency and transparency can also be used to express the degree of transmission of light. In this section of the report, the term opacity is employed because of its common use in the specification of light-scattering materials by ceramic, paper, paint and other technical groups.

Importance.—If the opacity of a cement filling is widely different from the opacity of tooth tissues, an optical unbalance is very noticeable. Zinc phosphate cement, which is so much more opaque than the tooth tissues, presents a dull and artificial appearance in comparison to silicate cement, the opacity of which can be adjusted to the opacities of the tooth tissues. It is this natural appearance of a silicate cement filling which is largely re-

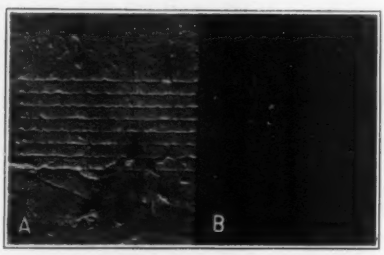


Fig. 17.—Section of disk of cement K, one half (A) of which was immersed in water two minutes prior to the time of setting. The other one half (B) was immersed in water four minutes after the time of setting. The series of parallel lines ruled across the surface of the specimen show the apparent differences between the two surfaces. The surface B did not seem to be affected by the water contact. The lines are approximately 0.4 mm. apart.

sponsible for its popularity and is probably the chief justification for the use of silicate cements. Hence, the desirability of accurately measuring both the opacity of silicate cements and of tooth tissues and of formulating precise numerical standards for the opacity of silicate cement.

Previous Work.—Hinderer and Spanner,[20] using a photo-electric cell, measured the percentage of light transmitted by different types of dental cements.

Preparation of Specimens.—Disks of cement approximately 1 mm. in thickness were made by pressing about 0.5 cc. of the plastic cement between two glass plates. Three minutes after the mix was started, the glass plates and the cement were transferred to an atmosphere having a relative humidity of 100 per cent at 37°C. (99°F.) and kept there for one hour. The specimens were then stored in distilled water at room temperature.

Instrument and Method of Measuring.—The Priest-Lange reflectometer[21] was selected for this work because determinations of the reflectances of small areas of enamel and dentin no larger than 2 square millimeters could be made with it.

The opacity of tooth tissue and of cement, both of which were always kept covered with distilled water, was determined by a method approximating the one described in the National Bureau of Standards Circular No. 63.[22]

Most of the cement specimens were approximately 1 mm. thick, but the tooth sections were often thinner because of the difficulty of obtaining a large enough flat surface area of enamel to make satisfactory reflectance determinations. All of the values for $C_{0.70}$ were adjusted to represent the opacity of specimens 1 mm. in thickness by a graphic method outlined in another paper.[23]

Discussion of Data.—A comparison of the relative opacities of seven-month specimens of silicate cement (Table 11, column 4) shows that they ranged from a 100 per cent opacity (cement F) to 23 per cent (cement K). Cement F is too opaque and, as will be subsequently shown, cements J and K are not opaque enough for general use.

A comparison of columns 3 and 4 in Table 11 shows that, in general, the cements become less opaque with time. With the exception of cements C and F, the seven-month specimens are less opaque than the one-week specimens. Cement C is very slow-setting and continues to react with water for comparatively

TABLE 14.—STAINING OF SILICATE CEMENTS WITH DYES

Class	Bases of Classification	Dyestuff		
		Methyl Violet B Colour Index 680 (Alkaline)	Rhodamine B Colour Index 749 (Acid)	Buffalo Black 10B Colour Index 294 (Acid)
		Cements		
I	Stained heavily throughout	J, L, H	H, B, L	B, A, H
II	Heavily stained on the periphery	A, B, G	E, G, A	G
III	Faintly stained	I, F, C, K	F, K, J, I, C	L, I, C, K, F
IV	Very faintly stained	D, E	D	D, J, E

long periods of time. Cement F is not a true silicate cement since it contains a large percentage of zinc oxide. (Table 2.)

The cements are relatively opaque when first placed in a tooth, but become less opaque with time, the greatest change occurring within twenty-four hours. This phenomenon has been observed by many dentists. When the cement is first placed in a tooth, it appears off shade, but overnight it changes and develops a natural appearance. Some dentists are in the habit of making a mix of cement and comparing it with the tooth in which a restoration is to be placed. Under such circumstances, a satisfactory comparison cannot be made because the cement becomes much less opaque with time. If the dentist desires to make his own shade guide,

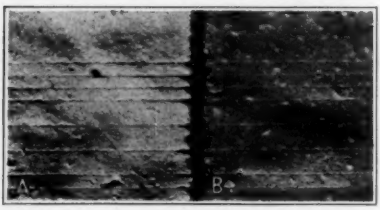


Fig. 18.—Section of disk of cement C, one half (A) of which was immersed in water four minutes prior to the completion of the normal setting time. The other half (B) was not exposed to water until twenty-six minutes after the time of setting. Both surfaces A and B have been damaged. The reaction between the powder and liquid of cement C is so sluggish that the cement must be protected from water for long periods. The shorter spaces between the lines are approximately 0.4 mm. apart.

the cement samples used in the preparation should be at least a week old.

The opacity of silicate cements naturally varies with color. The darker shades of cement are invariably more opaque than the lighter shades.

The thickness of a specimen has, of course, a pronounced influence on its opacity. The relationship between opacity and thickness is not a linear function, but is a complicated one.[23]

Measurements of the opacities of human tooth enamel and dentin (Table 12) were made in order to prescribe a satisfactory range of opacity for cements. The tooth sections were cut through areas involved in Class III and Class V cavities.

The data in Table 12 indicate that enamel and dentin are by no means uniform with respect to opacity. Enamel is in general less opaque than dentin. An average of all the measurements on enamel showed it to be about 39 per cent opaque and the average value for dentin was 70 per cent. Manifestly, it is not feasible to set any single value as a standard opacity for silicate cements and base it upon the opacity of human tooth tissues. (Table 12.) So, for a standard, a range of opacities must be permitted and it seems practicable to admit cements with an opacity range from 35 to 55 per cent to be certified for use in anterior teeth.

A method of placing a silicate cement restoration, ideal from an appearance standpoint, would seem to be to fill that portion of the cavity which lies in dentin with a 70 per cent opaque cement and then to fill that portion of the cavity which lies in enamel with a 40 per cent opaque cement; but obviously this is not feasible.

A comparatively opaque cement (50 per cent) can be used to advantage in certain types of cavities. For instance, in a large Class III cavity, a relatively opaque cement will minimize the influence of the dark background of the oral cavity. Conversely, a cement with a low opacity (25 per cent) is not suitable for large Class III cavities because its color and appearance are so affected by the dark background of the oral cavity that the restoration is easily visible.

In shallow Class III and V cavities with walls of solid tooth structure, a cement of low opacity can be used to advantage, because the tooth's shade is reflected from the walls and floor of the cavity and favorably affects the shade of the cement restoration. It is relatively

TABLE 15.—INDENTATION HARDNESS OF HUMAN TEETH AND DENTAL MATERIALS

Specimen	Material	Ratio of Applied Load to Area of Indentation		
		Kg./Mm.²		
		Low	High	Average
1	Enamel, buccal surface, lower first molar; enamel rods not fully in transverse section	280	322	299
	Indentations made at right angles to above	290	316	302
2	Enamel, transverse cross-section of crown, lower second molar; indentations parallel to long axis of enamel rods	255	290	275
	Indentations transverse to long axis of enamel rods	267	298	287
3	Enamel, incisal surface of lower central incisor	232	303	274
	Near dentino-enamel junction	232		
	Near buccal surface		265	
	Dentin	51	60	55
4	Dentin, transverse cross-section of root, lower second molar	60	63	61

		Average
Silicate cement		
	A	79
	C	54
	D	65
	E	67
	F	42
	F Dried out over night	55
	G	77
	J	68
	K	78
	K with 5 per cent petrolatum	60
	K with Durosim	60
	L	68
Zinc phosphate cement		40
Metals		
24 kt. rolled gold plate		41
22 kt. dark-rolled plate		85
Type C gold alloy, rolled plate as received		203
Amalgam, Specification type, hand-packed		109
Amalgam, Specification type, machine-packed		134
Amalgam, containing chromium and tungsten, machine-packed		85
Artificial fused porcelain tooth		465
Copper-nickel alloy (5 cent coin)		157
Noncorrosive microscope slide glass		477
Steel ball, commercial bearing		752
Steel gage block, hardened		880

easy to make a shade match between the cement and the tooth in this case. In order to overcome the effect of the dark background, some operators use a white cement or a white cavity lining in deep-seated cavities, in conjunction with a very translucent cement.[24]

Glass Standards for Opacity.—A set of alabaster glass plates of different thickness and therefore of different opacities were prepared (Figure 8) for use as comparison standards. The glass standards were prepared primarily to simplify the testing procedure and to save dental schools and manufacturers the expense of purchasing complicated equipment. Any optical shop can produce these standards at a reasonable cost. When the glass standards and a sample of cement were covered with water and placed side by side against a variegated black-and-white background, the opacity of the cement specimen was determined by visually comparing its contrast with those of the standard glass plates. Such determinations were made with an uncertainty of 2 per cent. For ordinary testing, this degree of accuracy is sufficient.

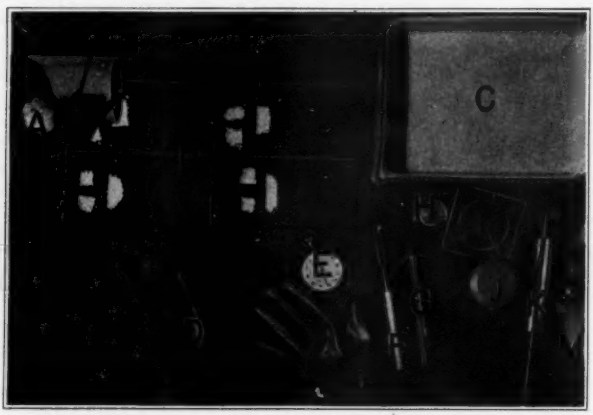


Fig. 19.—Top view of constant temperature and humidity cabinet, looking through glass window. A, fan. B, glass slabs with powder. C, tray for holding saturated salt solution. D, rubber gloves. E, stop watch. F, spatula. G, hypodermic syringe used for proportioning liquid. H, bottle of cement liquid. I, glass plate for use in consistency test. J, weight used in consistency test. K, Gillmore needle used in setting time determinations. M, light bulb for illuminating and heating cabinet. L, automatic bimetallic thermostat.

DIMENSIONAL CHANGE ON SETTING

Introduction.—The dimensional change which a restorative material such as a silicate cement undergoes when passing from a plastic to a solid state is a very important physical phenomenon. The ideal silicate cement in this respect would be one which has a slight initial expansion on hardening and then remains constant in volume. Such a cement effectively seals the cavity and prevents the ingress of substances, such as stains, solvents and micro-organisms, between the cavity wall and the filling material.

It so happens that the coefficients of thermal expansion of a hardened silicate cement[11] and of the hard tooth structures are about the same. Therefore, if a tooth containing a silicate cement filling is subjected to changes of temperature normally possible in the mouth, a crevice would not develop between the cavity wall and the filling, because cement and

TABLE 16.—EFFECT OF VARYING POWDER: LIQUID RATIO ON PHYSICAL PROPERTIES OF CEMENT K

TABLE 16.—EFFECT OF VARYING POWDER: LIQUID RATIO ON PHYSICAL PROPERTIES OF CEMENT K

Amount of Powder in 0.4 cc. of Liquid	Time of Setting at 37° C. (99° F.)	Compressive Strength at 1 Week	Solubility and Disintegration						Acidity at 1 Week	Shrinkage at 24 Hours	Opacity at 7 Months
			1 Week	2 Weeks	3 Weeks	4 Weeks	5 Weeks	Total			
Grams	Minutes	Lbs./In.²	Percentage by Weight						pH	Microns per Centimeter	Contrast Ratio* $C_{0.70}$
1.6	3.0	23,000	1.2	0.5	0.2	0.1	0.2	2.2	5.6	16.5	0.23
1.4	4.0	19,500	1.3	0.4	0.3	0.3	0.2	2.5	5.6	27.0	0.23
1.2	7.0	19,000	1.6	0.9	0.3	0.3	0.2	3.3	5.6	35.0	0.21

*The ratio is obtained by dividing the apparent daylight reflectance of light from a specimen 1 mm. thick when placed against a black backing by the apparent daylight reflectance obtained when the specimen is placed over a white backing, with an apparent daylight reflectance relative to that of MgO of 70 per cent.

tooth would expand and contract approximately an equal amount. In this respect, the silicate cements are much superior to metallic filling materials.

Previous Work.—Souder and Peters[11] used the interferometer, which they had adopted for measuring the linear setting and thermal dimensional changes of dental amalgam, for measuring similar changes in a silicate cement. Their data showed rapid contraction when the cement was exposed to air. Coating the specimen with varnish reduced the contraction markedly (from 0.88 to 0.34 per cent at the end of two and one-half hours). Specimens kept under water shrank from approximately 0.02 to 0.04 per cent. One specimen was allowed to remain in the air a short time before being placed in the instrument. This specimen had an initial expansion of about 0.01 per cent, followed by shrinkage, and at twenty-four hours had returned to approximately its original length.

Ray[25] conducted a series of experiments on five brands of silicate cement. Immersing the specimen in water immediately after the initial set (three minutes) of the unvarnished cement specimens reduced the contraction, and, in some cases, even caused an expansion followed by a contraction. The longer the specimens were exposed to air, the greater was the expansion after immersion in water. Ray also evaporated 10 per cent by weight of water from one of the cement liquids, and, in another instance, added to a cement liquid 5 per cent by weight of water, and then used these liquids in preparing specimens. Specimens made with the concentrated liquid expanded 0.12 per cent; whereas specimens made with the diluted liquid shrank 0.08 per cent.

Ray stated that the consistency of mix had little effect on the dimensional change on setting and demonstrated that old and completely set cement contracted enormously if left in dry air for some time.

Shrinkage in Air.—The shrinkage of silicate cements in air takes place rapidly

at first and continues for long periods of time at a much slower rate. It is believed that this shrinkage in air is caused by the loss of water from the cement, because, if precautions are taken to prevent or reduce the loss of water, the shrinkage is greatly reduced and, under some conditions, expansion may occur.

To determine the shrinkage of some of the silicate cements in air under controlled conditions, interferometer specimens were prepared by the standard mixing technic previously outlined. The mold in which the specimens were formed and the method of forming have been described.[7] The specimens were always in air at 21°C. (70°F.) and of 65 per cent relative humidity. The observations were be-

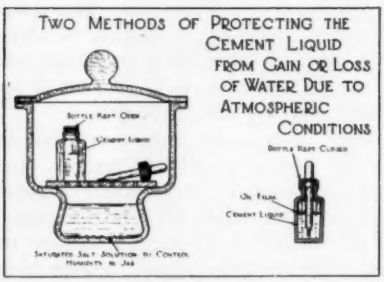

TWO METHODS OF PROTECTING THE CEMENT LIQUID FROM GAIN OR LOSS OF WATER DUE TO ATMOSPHERIC CONDITIONS
Bottle Kept Open
Bottle Kept Closed
Cement Liquid

Fig. 20.—Methods of maintaining moisture content of cement liquid.

gun immediately after the initial time of setting. Time (Fig. 9) was plotted on a logarithmic scale in order to show the changes in dimension over periods of time ranging from five minutes to 100 days. Readings were taken on the interferometer until the interference fringes were too numerous to count. Subsequent readings were taken with a micrometer caliper. Arrows on the curves (Fig. 9) indicate the end of the interferometer readings.

Of course, in actual usage, a cement should not be subjected to such conditions. However, in mouth breathers, silicate fillings may be subjected to rather long drying-out periods. Likewise, when a tooth containing a silicate cement filling is isolated by a rubber dam, a considerable amount of drying out and therefore of shrinkage may occur. This is the reason back of the manufacturer's request to protect with varnish a cement filling not covered with saliva for any extended period of time. Then, too, these and similar types of cements are recommended as model materials, and these data indicate that these cements are not well suited for model making, if exactness of dimensions is of importance.

The use of oily substances such as petrolatum and "Durosim" did not prevent shrinkage, but, in one particular case (cement K in air), the use of "Durosim" materially lessened the amount of shrinkage. A detailed discussion of the effect of an admixture of oils or greases in the cements is given in the section on "Effect of Oily Substances in the Powder and Liquid."

The "Mercurochrome Test."—During the years 1934 and 1935, there was revived, by sales promotion and a large-scale advertising campaign, a qualitative shrinkage test which consisted in plugging the end or the middle section of a glass tube with silicate cement and then filling up the remainder of the tube with a dye solution. If the dye solution penetrated between the glass wall and the silicate plug, the cement showed shrinkage. The cement was said to have expanded when no stain was visible between the glass and the silicate plug. This test was referred to as the "mercurochrome test" (Fig. 10), because the dye recommended for use in the test was an aqueous solution of mercurochrome. This test was a very popular one, as it could easily be conducted by the dentist in his own office and, on a superficial examination, did appear to indicate shrinkage or expansion. A closer scrutiny of the test procedure and the results, however, demonstrated that the conclusions might be very misleading. Cement C, which was a comparatively new one in this country, was practically

the only cement which prevented leakage. Consequently, many members of the dental profession were all agog over this test and the new cement.

The actual test procedure as stated in an advertising pamphlet follows:

the tube is then filled with whatever silicate you may be using, the silicate is allowed sufficient time to set, according to the manufacturer's directions, and the tube is then removed from the rod. This is to be your control. Now do the same with ————. Allow

TABLE 17.—EFFECT OF EXPOSING CEMENT LIQUID IN AIR FOR FIVE DAYS

Cement	Setting Time* of Cement When Made With			Percentage Gain (+) or Loss (−) in Weight of Cement Liquid		
	Original Liquid†	Liquid Exposed at 77 Per Cent Relative Humidity	Liquid Exposed at 32 Per Cent Relative Humidity	Exposed at 77 Per Cent Relative Humidity	Exposed at 32 Per Cent Relative Humidity	Loss in Weight Between 77 and 32 Per Cent Relative Humidity
	1	2	3	4	5	6
	Minutes	Minutes	Minutes	Per Cent	Per Cent	Per Cent
A	5.0	2.0	2.5	+7.5	+1.5	6.0
B	20.0	16.0	More than 30	+2.1	−6.3	8.4
C	17.5	12.0	21.0	+5.2	−2.1	7.3
D	6.0	9.0	More than 30	−2.9	−9.8	6.9
E	29.0	11.0	More than 30	+3.4	−3.0	6.4
F	11.0	6.0	13.0	+3.9	−2.7	6.6
G	15.0	4.0	More than 30	+3.0	−4.1	7.1
H	27.0	31.0	More than 30	−1.3	−8.8	7.5
I	18.0	14.0	More than 30	+0.7	−5.6	6.3
J	3.5	2.5	3.5	+1.3	−4.7	6.0
K	6.5	7.0	10.0	−1.7	−8.4	6.7
L	7.0	7.5	9.0	−1.7	−8.4	6.7

*Determinations were made at 21° C. (70° F.) and 65 per cent relative humidity.

†Data are not comparable to data in Table 6, column 3 because most of the materials used in the above tests were purchased two years later than the materials used in the tests reported in Table 6, column 3.

The Mercurochrome test is one that you can perform yourself in a few minutes. We will gladly send you the means to carry it out. A wooden rod is fitted into two cardboard discs. Over it is slipped a glass tube a little longer than the rod. The unoccupied end of not less than ten nor more than fifteen minutes to set. This simulates mouth conditions. Now fill both tubes with a solution of Mercurochrome, seal to prevent evaporation and allow both tubes to stand for an equal number of days. ———— Try it.

TABLE 18.—EFFECTS OF OILY SUBSTANCES ON THE PHYSICAL PROPERTIES OF CEMENT K

Column	1	2	3	4	5	6	7	8	9	10						11
	Powder: Liquid Ratio	Time of Setting		Compressive Strength	Shrinkage on Setting			Acidity‡‡		Solubility and Disintegration###						Opacity
		21°C. (70°F.)#	37°C. (99°F.)##	One§ Week	One Hour in Air**	One Hour in Water††	24 Hours in Water††	15 Minutes	24 Hours	1	2	3	4	5	Total	One Week
										Week						
	Grams‡	Minutes	Minutes	Lbs./In.²	Microns per Centimeter			pH	pH	Per Cent####						$C_{0.70}$§§
Cement K	1.4	6.0	3.5***	19,500	45	12	17	3.4	5.6	1.3	0.4	0.3	0.3	0.2	2.5	0.21
Cement K with Durosim*	1.3	5.5	3.5	14,500	13	9	12	3.5	5.2	1.1†††	0.6	0.2	0.2	0.2	2.3	0.25
Cement K with petrolatum†	1.7	6.5	4.5	13,500	28	8	13	3.5	5.6	1.7	0.8	0.4	0.3	0.2	3.4	0.33

*Durosim was added to the liquid in the ratio of 3 parts to 10 parts of liquid.
†Five per cent by weight of petrolatum was added to powder.
‡Grams of powder in 0.4 cc. of liquid which produced mix of standard testing consistency.
#Relative humidity of the air was 65 per cent.
§Specimens stored in distilled water at 37°C. (99°F.).
**At 21°C. (70°F.) with relative humidity at 65 per cent.
††At 37°C. (99°F.).
‡‡Of 25 cc. of distilled water (5.6—6.0) in which a cement disk 2 mm. thick and 20 mm. in diameter was immersed.
##Relative humidity of the air was 100 per cent.
§§Ratio of the daylight apparent reflectance of the cement with a black backing to the daylight apparent reflectance of the cement with a white backing having an apparent daylight reflectance relative to MgO of 0.70.
***Not identical with value for cement K, Table 6, column 4, because of slight variation among batches.
†††Values obtained with the Durosim cement mixture for the first week were very erratic, which indicates non-uniformity among specimens.
###At 37°C. (70°F.).
####By weight.

In considering objections to a test of this type, one should notice that a slow-setting cement, such as C, which had an initial time of setting (at room temperature conditions under which the test is conducted) of fourteen and one-half minutes (Table 6), will expand if water is allowed to come in contact with the cement before its initial setting time. When an aqueous solution of mercurochrome was placed on cement C before its initial setting time, the cement expanded rapidly, but, as shown in Figure 18, the cement is irreparably damaged on premature contact with water. This appears to be true for all of the silicate cements included in this report. Many of the more widely used cements have a much shorter setting time than cement C, so that if cement D (initial setting time, four and one-half minutes at room temperature conditions) was tested against cement C in the manner prescribed for the "mercurochrome test," the specimen of cement D would probably be from sixteen to twenty-one minutes old (approximately four to five times its initial setting time) before the mercurochrome solution was poured into the tube. Figure 9 shows that the shrinkage of a twenty-minute old specimen of cement D in air (21° C. [70° F.] and 65 per cent relative humidity) was approximately 0.3 per cent. If a similar specimen of cement C is exposed in air for one hour (approximately four to five times its initial setting time), its shrinkage is approximately 0.3 per cent. A rapid-setting cement is thus penalized when the test is conducted as directed.

In the "mercurochrome tests" conducted at the National Bureau of Standards in accordance with the foregoing directions, cement C had the best rating. Cements E and H were next. Most of the cements appeared to shrink badly. Here, it should be noted that the size of the lumen (internal diameter of the tube used in the foregoing experiments was 7 mm. [0.28 inch]) of the glass tube may have a considerable influence on the comparative rating of cements with the "mercurochrome test."

It was observed that the ends (to a depth of about 1 mm.) of the plug of cement C, which were in contact with the aqueous dye solution, were swollen and fitted tightly against the tube walls; whereas the cement between the two ends and not in contact with water pulled away leaving a space between the wall of the glass tube and the middle portion of the outside surface of the cylindrical cement plug. (Fig. 10.)

The test was repeated using a larger glass tube (internal diameter about 13 mm. [0.5 inch]), so that the space caused by the shrinkage was proportionally larger. It was thought that by drilling a channel along the glass-cement margin into this shrinkage space from one surface of the specimen, which was in contact with the aqueous dye solution, a connection could be established between the space and the solution, and that the space would then fill with the solution. This could not be accomplished because the dye solution followed the drill and caused the cement to swell along the glass-cement margins and to seal the channel as soon as it was made. The expansion of the cement in this instance was so great that the glass tube was cracked.

When the dyestuff was dissolved in water-free alcohol or benzene and cement C was subjected to the same test, the dye penetrated between the glass and the cement. It was concluded that surfaces of specimens of certain silicate cements (notably the slow-setting cements C, E and H) swelled on contact with water; whereas the portions of the specimens not in contact with water shrank. This indicated that the size and shape of a specimen might have an influence on its dimensional change on setting in water.

Volumetric Changes.—The effect of the size and shape of a specimen on its volumetric changes was proved by conducting some experiments on different shaped specimens of the same cement.

These changes were determined on an analytic balance provided with a magnetic damping mechanism by means of which it was possible to make rapid determinations of the weight and changes in weight of the specimen when submerged in water. The sizes of the specimens used in experimental determination on this balance were a sphere approximately 10 mm. (0.4 inch) in diameter and a disk about 50 mm. (2 inch) in diameter and 0.4 mm. (0.016 inch) thick. These specimens, although differing in shape and surface area, are of approximately the same volume. The sphere presents the minimum amount of surface area for a given volume; whereas the disk has a relatively large surface area for a given volume. The changes which occurred prior to the initial reading could not be recorded and may be large. Considerable shrinkage occurred when the specimen was exposed to air during its preparation and insertion in the instrument.

The spherical specimen contracted and the disk expanded, this confirming the theory that the dimensional changes observed in the "mercurochrome test" are surface phenomena.

Measurement of Triangular Rods.—The surface swelling of cements indicated that perhaps for some cements the dental amalgam interferometer was not a suitable instrument for measuring the dimensional change on setting, because a film of water might penetrate between the ends of the specimen and the interferometer plates and cause a localized reaction or apparent expansion. This would give a false value for the dimensional change. Consequently, another instrument (Fig. 11) was designed. This instrument is constructed so that the specimen can be formed *in situ,* and so that the measuring contacts or anchor plates are within the specimen; which makes it possible to subject the specimen to any desired treatment without affecting the contacts used for measuring dimensional changes. Fixing the specimen to the instrument prevented water from penetrating between the ends of the specimen and the contacting parts of the measuring instrument. The change in dimension was noted on a dial gage, the smallest scale division of which was 0.0001 inch (approximately 2.5 microns). The tension exerted by a rubber band strung from the top of the dial to the actuating lever was so adjusted that it neutralized as nearly as possible the tension occasioned by the spring pressure and friction of the dial parts.

A specimen with triangular cross-section about 2.5 cm. (1 inch) long and with equal sides approximately 1 cm. (0.4 inch) wide was employed in the instrument.

All cements tested in this instrument showed shrinkage (Table 13, last column).

Effect of Alternate Wetting and Drying.—With the mechanical indicator (Fig. 11), the effect of alternate wetting and drying of cement K was, respectively, shrinkage and expansion. The final dimensions of the restoration will be smaller than the original dimensions when it is subjected to the preceding treatment.

This procedure of alternately drying and wetting is somewhat similar to the treatment accorded a silicate cement filling in a mouth breather.

Small Specimens.—To test specimens which were comparable in size to a small filling, a special interferometer (Fig. 12) was designed. The novel feature of this differential interferometer is that it permits a speedy adjustment so that readings may be made very soon after the initial setting of the cement.

The supplemental pin (J, Fig. 12) permits the use of a small cylindrical specimen about 2 mm. (0.08 inch) in diameter and 5 mm. (0.2 inch) long. When the cylinder was placed on its side, the effective dimension over which the linear change was measured was approximately 2 mm. (0.08 inch).

Effect of Time of Contact with Water.—The data obtained at mouth temperature on this adjustable interferometer are considered to be nearly representative of actual mouth conditions.

In Figure 13, the effect of the time of contact with water on the linear dimensional change of cement C is strikingly demonstrated. Because of the slow-setting reaction of this cement, it is not safe to expose it to water even twenty-six minutes after its initial setting time. (Fig. 18.) These results (Fig. 13) may explain Ray's[25] findings that a shrinking cement can be made to expand by using a more concentrated liquid, because a cement made with a liquid more concentrated than normal usually hardens more slowly than a cement made with the normal liquid. If both the cement made with the normal liquid and the cement made with the more concentrated liquid were exposed to water at the same time, the slower-setting cement would, of course, expand.

To complete the reaction between the powder and the liquid, a definite amount of water is needed in the liquid. The amount required varies with the composition and the fineness of the powder. If the correct amount of water is not present in the liquid, the mixed cement has an affinity for water. The reaction between the partially hardened cement and the water produces the surface swelling. The severity of this reaction depends on how hungry the partially hardened cement is for water and on the time interval between the beginning of the mixing and the contact of the mixed cement with water.

Figure 14 shows the dimensional change on setting of six cements (A, C, D, E, K and J) in microns per 2 mm. (To convert to percentage, multiply by 0.05.) It is doubtful that one can accurately predict what dimensional changes will occur in actual dental practice as these will depend on many variables in the mixing technic, the stability of the cement liquid under conditions of mixing, the size and shape of the filling, the time of exposure to air before a varnish or other protective coating is applied, the time at which saliva comes in contact with the restoration and no doubt on other conditions which were not observed. The cements are so sensitive to these influences that it is difficult to obtain uniform test results, and extreme care must be exercised in controlling the testing procedure. It is not practicable for the dentist to do this.

These data (Fig. 14) show that excessive expansion can occur. Certain combinations of conditions affect this expansion. For instance, excessive expansion will probably result if (1) a slow-setting cement is mixed to a thin consistency; (2) a small specimen having a relatively large surface area for its volume is used, or (3) a specimen is subjected to water before it has hardened sufficiently.

Table 13 shows the influence of the size and shape of the specimen on its dimensional change. The ratios of the surface area of the specimen to its volume for the specimens 2, 10 and 25 mm. (0.08, 0.4 and 1 inch) long are 2.4, 1.00 and 0.77, respectively. In general, the smaller the amount of the surface area of a specimen in contact with water in proportion to its volume, the less the expansion. This does not hold true for cement D. Cements C and E are extremely sensitive to water, and hence their dimensional changes on setting are greatly affected by the relative proportions of surface area and volume of a restoration.

DYE PENETRATION TESTS

History.—Dyes of various types have been used for years in the testing of dental cements for porosity, permeability and dimensional change. Among the earliest investigators was Tomes, who, according to Flagg,[26] suggested the use of dyes and, in 1860 or thereabouts, used dyes in shrinkage tests on amalgam. Much of the experimental work in which dyes were employed in testing cements was poorly conducted and, as a result, faulty conclusions regarding the suitability of the various cements were often reached. Some investigators believed that by immersing a cement specimen in a dye solution, such properties as density, the relative porosity and permeability could be determined by

the brilliance and depth of penetration of the stain in the specimen.

Discussion of Behavior of Dyes on Silicate Cements.—Some of the factors which should be considered when employing dyes in the testing of the silicate cements are:

1. Type of dye. Some of the common dyes are weakly acid in aqueous solution; others are slightly alkaline. The silicate cements are acid in reaction, especially during their early hardening period, when a dye test is usually begun. If an acid reacting cement is placed in an acid dye solution, the amount and degree of staining are small as compared to the staining when an alkaline dye solution is used.

2. Precipitation. Some of the constituents of the cement liquids, probably the acid phosphates of zinc and aluminum, precipitate certain dyes, forming insoluble lakes or pigments. Fleck[27] suggested that any dye which was to be used in staining dental cements should first be tested by adding a few drops of the cement liquid to a small quantity of the dye solution to determine whether the dye would be precipitated. Dibrom-oxymercury-fluorescein (mercurochrome) is a dye of this type and it will be precipitated. In 1902, Fleck[27] cautioned against the use of dyes of the fluorescein group because of this. Recently, in discussing a much publicized "shrinkage test" which employs an aqueous solution of mercurochrome, Mamlet[28] demonstrated that this dye was precipitated by phosphoric acid. If a pellet of cement is submerged in an aqueous solution of mercurochrome, the surface of the pellet becomes covered with a layer of the precipitated dye. This precipitate is somewhat gelatinous and seems to act as a semipermeable membrane, which filters out the color of the dye, leaving only a clear liquid to penetrate the cement. This clear liquid, of course, does not stain the cement.

3. Surface penetration. The surface area of specimens of some cements swells when brought into contact with water or with aqueous solutions. This swollen surface is softer than the interior of the cement specimen and appears to act as a barrier preventing the penetration of the dye. A cement which is subject to this surface swelling will usually have a thin heavily stained layer when a specimen is immersed in a dye solution. If the specimen is quickly broken and again dropped into the dye solution, the surfaces of the fracture area will stain. This indicates the formation of something which limits the penetration of the dye.

4. Indicators. The color of certain dyes changes or is obliterated in the presence of acid or alkaline materials. These dyes should be avoided in tests of this nature.

5. Solvent. The use of alcoholic instead of aqueous solutions of dyes does not seem proper, because alcohol is not a natural constituent of the saliva.

6. Drying. If a cement is allowed to become dry and is then subjected to a dye test, it will be stained throughout the specimen. The surfaces of cement fillings in the mouth will occasionally become dry. This may account for some of the staining which occurs in the mouth.

7. Treatment. The method of preparing the test pieces and their time of immersion in dye solution may also have a pronounced effect on the character and degree of staining.

Testing Procedure.—In tests conducted during this study, 0.2 per cent aqueous solutions of three dyes were used; namely, Buffalo black -10B, Colour Index No. 294 (acid), methyl violet B, Colour Index No. 680 (alkaline) and rhodamine B, Colour Index No. 749 (acid). None of these dyes were precipitated by the cement liquid. Each specimen which was stored in a dye solution for one month at 37° C. (99° F.) was planed flat on one side by grinding with carborundum powder suspended in water. The differences in the depth of penetration and the intensity of the staining were of such magnitude that the ce-

ments could be arbitrarily grouped in four classes. (Table 14.)

Discussion of Results.—All of the cements stained to some extent in all three of the dyes, but the basic dye (methyl violet B) stained the cements more than did the two dyes having an acid reaction. Buffalo black 10B stained the least of the three dyes.

The effect on the staining of cement K after the addition of 5 per cent by weight of petrolatum[29] U.S.P. to the powder before mixing was studied. The specimens containing the petrolatum stained slightly more than those made without it.

TEMPERATURE RISE ON SETTING

The quantity of heat developed during the initial hardening of a silicate cement should not be large because of possible damage to the pulp of the tooth by thermal shock. No attempt was made to measure the actual heat generated, but the rise in temperature of the cement on setting was determined. The method and apparatus employed in this determination are the same as those used in the investigation of the zinc phosphate cements.[8]

In the case of cement A, the increase in temperature 22.5° C. (40.5° F.) above body temperature is alarming, and it may be even larger because the maximum rise may have occurred before the first reading was taken. If such a cement were used to fill a crown form prior to insertion over a porcelain jacket preparation, the pulp would probably be injured and certainly discomfort would be felt from this thermal shock. It should be noted that the composition of the powder of cement A is distinctly different from that of the others (Table 2). The temperature rise of the other cements is not of sufficient magnitude to injure the pulp when the size of the mix is taken into consideration. No definite relationship between the maximum temperature rise and setting time was observed.

In order to determine the effect of a short mixing time, as recommended by Eberly,[29] on the temperature of a cement during mixing, cement K was mixed according to the standard technic, except that all of the powder was added to the liquid at one time and the mass was spatulated for thirty seconds. The temperature rise on setting was found to be slightly less than that obtained when the standard mixing time (one minute) was used. This can probably be explained by assuming that the powder particles were not broken down so much in the thirty-second mix as in the one-minute mix and would, therefore, present less surface of the powder for reaction to the liquid.

DISCOLORATION

Another major defect of silicate cement restorations is the instability of the color of the cement in the mouth. Clinical observation has shown that none of the cements are immune from discoloration, and that often, after a few months of service, the restoration will change from its natural toothlike color to a dingy brown.

Tests.—Hydrogen sulfide (H_2S) has been used for years in discoloration tests on dental restorative materials, especially amalgam. Unoxidized sulfur is undoubtedly frequently present in the mouth because so much of the protein foodstuff contains sulfur. This unoxidixed sulfur readily combines with such base metals as copper and lead, forming dark sulfides.

To determine the relative amount of darkening of the silicate cements in the presence of unoxidixed sulfur, small disks (about 20 mm. [0.8 in.] in diameter) of the cements were made in duplicate. One set was suspended by means of silk floss in a hydrogen sulfide atmosphere for twenty-four hours at 20-25° C. (68-77° F.). The other set of disks was preserved in distilled water. Great care was exercised in making the disks so that they would not be contaminated with any substances which would react with hydrogen sulfide to form dark colored sulfides. The disks were not touched with the hands. The disks were suspended in the gas, and

not in water saturated with hydrogen sulfide, because the sulfides formed might be soluble in hydrogen sulfide solution.

In Figure 15 are shown the exposed and unexposed disks of each silicate cement. Each cement darkened on exposure to hydrogen sulfide. Cements E, F and G darkened the greatest amount. The colors of cements D and K changed the least. The use of oily substances such as petrolatum or castor oil in the cement mix did not seem to increase the tendency of cement K to discolor.

Cements N and O are zinc phosphate cements. Cement O contains a copper salt which is said to impart germicidal properties to the cement. The addition of such base metal salts or silver salts will, of course, cause the cement to darken badly in the presence of hydrogen sulfide because of the formation of dark colored sulfides.

The surfaces of the silicate cement disks did not appear to be attacked, as the original gloss of their surfaces was observed after completion of the test. The zinc phosphate cements were softened and disintegrated to a considerable extent by the hydrogen sulfide.

It is believed that the degree of freedom of the cement powder and liquid from copper, lead and similar metals which have dark colored sulfides is an index of the degree of freedom from discoloration in hydrogen sulfide.

HARDNESS

The scratch hardness of tooth tissues has been quantitatively reported by Hodge[30] for enamel, dentin and silicate cements.[25] The scratch hardness methods were probably used in many of the investigations because there was not available a reliable quantitative method, but lately there have been developed at the National Bureau of Standards a suitable instrument and method for determining the hardness of glasslike substances by the indentation method.[31]

The indentation is made by pressing into the substance under test the apex of a four-sided diamond pyramid. The base of the pyramid is in the shape of a rhombus with the long diagonal about ten times the length of the short diagonal.

The length of the indentation was measured and from the length and the angles of the pyramid, the lateral area of the impression was calculated. The applied load in kilograms, divided by the area in square millimeters, gives a ratio ($kg./mm.^2$) which is here used to designate the relative hardness of the material. The ratios for enamel, dentin, silicate cements and other materials as determined by the foregoing method are shown in Table 15.

Not enough measurements were made to justify conclusions regarding the differences in hardness of tooth structures in health or disease, or the hardness of enamel or dentin in different sections of a tooth, etc., but the data and illustrations do show that the instrument and method are satisfactory for this purpose and should prove to be a useful tool in studying certain physical characteristics of hard tissues.

The data (Table 15) also show the marked difference in hardness of enamel and dentin and that the hardness of silicate cements (year-old specimens) is not much greater than that of dentin. Other data obtained by the originator demonstrate that results consistent within about 1 per cent can be obtained.

Figure 16 shows the relative sizes of the indentations in enamel and dentin near the dentino-enamel junction. Some shattering of the enamel is visible. It was very difficult to polish adjacent areas of dentin and enamel and keep them in the same plane so that a satisfactory photomicrograph could be made. If the enamel was highly polished, no fracturing of the enamel occurred.

The measurements were made by Frederick Knoop, of the National Bureau of Standards, using the microhardness method and apparatus devised by him.

EFFECTS OF PREMATURE EXPOSURE TO WATER

Dental silicate cements, like the zinc phosphate cements, are not hydraulic; *i.e.*, they will not harden properly under water or saliva. If water or saliva comes in contact with them before the initial hardening has occurred, the cements will be irreparably damaged. This behavior is easily explained when one recalls that phosphoric acid (H_3PO_4) is the major constituent of the cement liquids (Table 3) and that phosphoric acid has a great affinity for water. Thus, when a cement the initial setting of which is incomplete is exposed to water, some of the uncombined phosphoric acid of the plastic cement mix unites with the water and interferes with the chemical reaction between the powder and the liquid, an extremely unsatisfactory cement resulting.

To demonstrate experimentally the effect of premature exposure to water, a thin disk of plastic cement (K) was formed by pressing a mix of cement between two glass plates. About one half of the flat surface of each side of the disk was protected with a thin sheet of waterproof cellophane. The other half of the disk was unprotected. Four minutes after mixing (which was two minutes before the completion of the normal setting time of cement K under the specific conditions of mixing used [Table 6]), the disk was submerged in water. Ten minutes after mixing was started (four minutes after the normal setting time) the disk was withdrawn from the water temporarily and the cellophane coating was removed from the protected half. The disk was then replaced in the water and left for one week. A photograph of a section of the surface of this disk (Fig. 17) showing the physical condition of both the protected and unprotected sides illustrates the great amount of injury that occurred. A in Figure 17 represents the prematurely exposed portion of the disk. It has a soft white chalky surface which is easily abraded and is much less translucent than B, the protected half. A series of parallel lines were ruled across the specimen after the test to show the apparent difference in hardness and texture of the two surfaces.

A similar experiment using cement C was made. The time of setting of cement C under the conditions of this test is fourteen and one half minutes (Table 6, column 3). The unprotected half of one face of the cement disk (A, Fig. 18) was exposed to water ten minutes after beginning the mixing; *i.e.*, four minutes prior to the completion of the normal setting time. The other half of this face of the disk (B, Fig. 18) was not exposed to the water's action until forty minutes after the beginning of the mixing (twenty-six minutes after the initial setting time). The surface of cement C was damaged in a similar manner to that of cement K on the prematurely exposed surfaces. There even seems to be some effect on the surface which was not exposed to water until about twenty-six minutes after the setting time. This may possibly be explained by the chemical analysis of the liquid of cement C (Table 3), which shows it to have a high phosphoric acid and low water content. This type of liquid reacts with the powder slowly and thus makes the cement susceptible of damage for a longer period of time. As was explained in the discussion of dimensional change on setting, such a cement may have a surface expansion, but of what benefit is an expansion when it is obtained only at the expense of other valuable properties?

EFFECT OF VARYING POWDER:LIQUID RATIOS

The amount of powder which one mixes with a definite quantity of liquid affects the physical properties of the cement, but the magnitude of change caused by varying the powder:liquid ratio of dental silicate cement does not seem to have been published.

In order to determine quantitatively

what variations in physical properties occurred in changing the powder:liquid ratios, cement K was tested at three different ratios: (1) at the standard testing consistency used in this report, *i.e.*, 1.4 gm. of powder in 0.4 cc. of liquid; (2) at a thicker or heavier consistency than standard; *i.e.*, 1.6 gm. of powder in 0.4 cc. of liquid, and (3) at a thinner or lighter consistency than standard, *i.e.*, 1.2 gm. of powder in 0.4 cc. of liquid. Consistency No. 1 ($\frac{1.4 \text{ gm.}}{0.4 \text{ cc.}}$) is the approximate average consistency used by a group of dentists who cooperated with this laboratory in conducting a series of experiments. Consistency No. 2 ($\frac{1.6 \text{ gm.}}{0.4 \text{ cc.}}$) is too dry and stiff to use conveniently. Consistency No. 3 ($\frac{1.2 \text{ gm.}}{0.4 \text{ cc.}}$) is definitely too thin (Fig. 3).

It is possible that the foregoing statement is applicable only to those batches used in this investigation, because, among the forty-one cooperating dentists who prepared experimental mixes with this cement, one reported that he used 1.82 gm. of powder in 0.4 cc. of liquid, and another reported that he used only 0.98 gm. of powder in 0.4 cc. of liquid. Even allowing for batch variations and differences in the mixing environments, it is very evident that neither dentist is using the cement to the best advantage, because the 1.82 gm. mix will probably be too heavy and dry and cannot be well adapted to the cavity; whereas the 0.98 gm. mix will have very inferior physical properties.

Data on certain physical properties of cement K at these three different powder: liquid ratios (Table 16) show that the time of setting, compressive strength, acidity and opacity are not affected seriously when considered from a practical clinical standpoint. However, it is very important to note the progressive increase in the solubility and disintegration and the shrinkage, with a decrease in the powder: liquid ratio. This is of special significance because the silicate cements have inherently low values for these properties, and any manipulation which will increase the normal solubility and disintegration and the shrinkage should be constantly avoided.

EFFECT OF HUMIDITY OF THE AIR ON THE CEMENT LIQUID

Importance.—The water content of the cement liquid is important; *i.e.*, it cannot be changed greatly without unbalancing the reaction between the powder and liquid. The cement liquids gain or lose water in accordance with the humidity of the air to which they are exposed. The reason the cement liquids are subject to fluctuations in their water content is that they are essentially aqueous solutions of phosphoric acid containing various amounts of dissolved salts (Table 3). Phosphoric acid solutions of this type always tend to come into equilibrium with water vapor in the air, and change their water content in so doing. This property is a serious disadvantage in the practical use of the silicate cements because the gain or loss in the water content of the liquid produces an excessive acceleration or retardation, respectively, of the setting time. Holmes[32] reported data which show the extreme susceptibility of the cement liquids to humidity changes.

Experimental Procedure.—Approximately 8 gm. of each liquid was placed in a tarred glass-stoppered weighing bottle (inside diameter about 37 mm [1.5 inches]). Each bottle was stoppered and immediately weighed. This weight less the original weight of the empty bottle (with stopper) was taken as the weight of the cement liquid. The bottle was then placed in a desiccating jar, the bottom of which was filled with a saturated solution of common salt (NaCl). This solution will maintain a relative humidity of about 77 per cent over a temperature range of 20° C. - 25° C. (68° F. - 77°F.). The weighing bottle was unstoppered and the lid of the desiccating jar was put in place. After an exposure of approximately 120 hours, the weighing bottle was stoppered, withdrawn from the jar and reweighed. The gain or loss in weight

(it is assumed that this is gain or loss in water) expressed in percentage is shown in Table 17, column 4.

The experiment was repeated, a saturated solution of $MgCl_2 . 6 H_2O$ (magnesium chloride 1 part to 6 parts water) being placed in the bottom of the desiccating jar. This solution will maintain a relative humidity of about 32 per cent over a temperature range of 20° C. - 25° C. (68° F. - 77° F.). The data are shown in Table 17, column 5.

Discussion of Data.—It is interesting to note that the liquid of cement A gained in weight when exposed to either a high or a low humidity. The affinity of this liquid for water indicates a high content of phosphoric acid, which was later confirmed by chemical analyses. (Table 3.)

Four cement liquids, D, H, K and L, lost water at both the high and low humidities, the loss being greatest, of course, at the lowest humidity (32 per cent). This indicates a comparatively low phosphoric acid content. Chemical analyses of these liquids showed this to be true. (Table 3.)

All of the other cement liquids, B, C, E, F, G, I and J, gained water in a relative humidity of 77 per cent and lost water in a relative humidity of 32 per cent. These liquids would be in equilibrium at some relative humidity between 77 and 32 per cent. Cement liquid I was almost in equilibrium with a relative humidity of 77 per cent, since it gained only 0.7 per cent after a 120-hour period of exposure.

The total amount of change of each cement liquid is shown in Table 17, column 6. Attention should be directed to the fact that cement liquid C was said to be immune from influences of this type. The manufacturer's advertising stated that "atmospheric changes affect neither the powder nor the liquid." The foregoing data (Table 17) show this to be without basis in fact since not only was cement liquid C affected by humidity changes, but also its total amount of change (7.3 per cent) was exceeded by that of only two other cement liquids of the twelve investigated.

Effect of Water Content of Liquid on Setting Time.—The setting times of the cements were determined with (1) the original liquid; (2) the liquid exposed to air having a relative humidity of 77 per cent and (3) the liquid exposed to air having a relative humidity of 32 per cent. The data (Table 17, columns 1, 2 and 3) present many interesting facts. Cement liquid A, having gained water in both humidities, afforded a faster-setting cement than normal in both instances. Cement liquids B, D, E, G, H and I were so affected by exposure to a 32 per cent humidity that the resulting cements would not harden in thirty minutes. These same cements when mixed with the liquids which were previously exposed in air at 77 per cent relative humidity were not seriously unbalanced. The setting times of cements A, J, K and L were not seriously changed. This is a very important practical point, indicating the comparative stability of these cements under adverse conditions.

Methods of Preserving Liquids.—Some of the bottles of powder contained approximately 14 gm. (one-half ounce) of material. If it is assumed that each mix required approximately one-fourth gram of powder, there would be about sixty mixes in a bottle of powder, which would mean about sixty withdrawals from the liquid bottle. If each withdrawal required only thirty seconds, the liquid would be exposed about thirty minutes during the life of the bottle. Unfortunately, such an ideal condition seldom exists. Sometimes, the operator forgets to replace the stopper in the liquid bottle. Some of the ground-glass stoppers do not fit accurately, and leakage often occurs from this fault. One manufacturer suggests coating the ground-glass joints with a thin film of petrolatum. This seems to effectively seal the joint.

A suggestion of the authors which

seems quite practicable is to place a few drops of a fine neutral oil in the bottle of liquid. (Fig. 20.) Light liquid petrolatum U.S.P. seems to be satisfactory for this purpose. The oil spreads in a thin film, which effectually prevents a serious unbalancing of the water content of the liquid, as was proved by the following experiment: Cement liquid A, which had increased in weight 7.5 per cent when exposed to a relative humidity of 77 per cent for 120 hours, showed a gain of only 0.13 per cent when protected by an oil film, even though the specimen was exposed under the same conditions for seventeen days. When the humidity was held at 32 per cent, the oil-protected liquid lost only 0.13 per cent in weight when exposed for seventeen days, as compared to a gain of 1.5 per cent of the unprotected liquid. The loss or gain in weight when the liquid was protected by the oil film was so negligible that the setting time of the cement was not changed.

In practical use, the dropper or pipet should be inserted beneath the oil film before any liquid is drawn into the tube of the dropper and then the outside of the dropper should be wiped off with a cloth to remove excess oil. The small amount of oil which might contaminate the mix does not seem to harm the physical properties of the cement.

It is suggested that if the dentist desires to try this method, he should proceed cautiously and at first place a series of trial fillings in the mouth and observe them over a period of several months, since our laboratory tests may not have detected some fault which may be discovered in clinical tests.

Another suggestion is to keep the bottle of cement liquid unstoppered in a jar with a tightly fitting cover. The bottom of the jar should contain a saturated solution of some salt which will produce a humidity in which the cement liquid does not show an appreciable change. For example, it was determined that cement liquid D was stable in air having a relative humidity of 80 per cent. To produce and maintain this humidity, a saturated solution (there must be some undissolved crystals in the solution) of ammonium chloride (NH_4Cl) is kept in the bottom of the jar. Different cement liquids would require different degrees of humidity to maintain constant weight. This could be determined for each liquid by its manufacturer.

The proper care and preservation of the cement liquid is one of the cardinal factors in the successful use of dental silicate cements.

EFFECT OF OILY SUBSTANCES IN THE POWDER AND LIQUID

Previous Work.—Within the last three years, several investigations on the use of oils and petrolatum in silicate cement mixes have been reported. Eberly,[29] in some of his experiments, incorporated 5 per cent of petrolatum (by weight) in the silicate cement powder before mixing the powder and liquid. He reported that the addition of the petrolatum did not seriously interfere with the reaction between the powder and the liquid, nor with the shade, and gave a more pleasing appearance to the cement restoration. Further, the addition of the petrolatum to the cement reduced the acidity of the washings from the cement from a pH of 5.5 to a pH of 6.2. Cement containing petrolatum did not dry out rapidly when exposed to the air and was found to stand up well in the mouth.

In Germany, a material called "Durosim" (U. S. Patent No. 1,886,982, Nov. 8, 1932), which is added to the silicate cement liquid just prior to mixing, has been developed. Within the last few years, attempts have been made to market the product in this country. Durosim appears to be an oily liquid and gives off an odor strongly suggestive of castor oil.

Saenger[33] reported that there was less irritation of the pulp under silicate cement fillings when durosim was used.

Walter[34] believes that the addition of Durosim greatly benefits the silicate cement and in fact has solved the so-called silicate cement question. Both of these reports are very optimistic about the benefits derived from the use of Durosim.

Tests.—In order to compare the physical properties of silicate cements with and without the use of petrolatum and Durosim, the following tests were made.

Consistency.—At the standard testing consistency, about 1.4 gm. of cement K powder can be incorporated in 0.4 cc. of liquid. (Table 18, column 1.) When Durosim is added to the liquid just prior to mixing in the approximate ratio of three parts of Durosim to ten parts of the cement liquid, 1.3 gm. of powder could be incorporated. With the addition of 5 per cent of petrolatum to the powder before mixing, 1.7 gm. of powder was required to produce a mix of standard testing consistency. (Table 18, column 1.) Normally, such an increase in the powder:liquid ratio would have a pronounced beneficial effect on the physical properties of cement K. (Table 16.) However, in this instance, it will be shown that this is not necessarily true.

Time of Setting.—The times of setting under either room or mouth conditions were not critically affected by the presence of oily substances. (Table 18, columns 2 and 3.) This result seems incredible, but the addition of oil does not sufficiently retard the reaction between powder and liquid to change materially the setting time.

Compressive Strength.—Under the test conditions specified in the section on compressive strength, cement K, when mixed at the standard testing consistency, had an ultimate compressive strength of about 19,500 pounds per square inch at the end of one week. The addition of Durosim reduced this normal strength about 25 per cent. The addition of petrolatum reduced the normal strength about 30 per cent. (Table 18, column 4.) These large reductions in strength may not be significant when it is considered that silicate cements in Class III or Class V cavities do not fail under compressive forces to which they might be subjected in the mouth. On account of their brittle nature, the silicate cements cannot be used in any other than well protected cavities.

Dimensional Change During Setting.—A series of tests using the interferometric method were conducted on cylindrical specimens (10 mm. [0.4 inch] long and 5 mm. [0.2 inch] in diameter) exposed to air and on others placed under water. In Table 18, column 5, it will be noted that the shrinkage of cement K in air having a temperature of 21°C. (70°F.) and a relative humidity of 65 per cent was 45 microns per centimeter (0.45 per cent) at the end of one hour. The addition of Durosim reduced the shrinkage to 13 microns per centimeter (0.13 per cent), or about 70 per cent. The specimen containing petrolatum shrank only about 28 microns per centimeter (0.28 per cent), a reduction of about 40 per cent from the shrinkage of the normal cement under like conditions of test. The oily substances very materially reduced the shrinkage during one hour. However, over a long period of time, the presence of the petrolatum did not materially affect the amount of shrinkage in air (Fig. 9). The differences of the shrinkages were much smaller for the specimens in water at 37° C. than for those in air. (Table 18, columns 5, 6 and 7.) Under water, at the end of one hour, the normal cement K had shrunk only 12 microns per centimeter (0.12 per cent); cement K with Durosim, 9 microns per centimeter (0.09 per cent), and cement K with petrolatum, approximately 8 microns per centimeter (0.08 per cent). In this instance, the addition of the oily substances reduced the shrinkage 25 per cent.

At the end of twenty-four hours, the shrinkages for the normal, Durosim and petrolatum-containing specimens were 17, 12 and 13 microns per centimeter re-

spectively (0.17, 0.12, 0.13 per cent). The shrinkage of the oil-containing cements (under water) was about 30 per cent less than the shrinkage of the normal cement. This shrinkage seems large and significant when calculated in percentage. However, if the slight changes in the dimensions of actual restorations are considered, one realizes the extremely small differences. For instance a calculation of these shrinkages in a large class III silicate cement restoration in the proximal surface of a central incisor (if it is assumed that the major linear dimension of the restoration is 4 mm. [0.16 inch]) gives 7 microns shrinkage for the normal cement K, about 5 microns for the Durosim containing cement K and slightly over 5 microns for cement K with petrolatum. When the properties of silicate cements and the difficulty of preparing uniform test specimens or fillings are evaluated, these differences are not of any practical significance.

In the case of mouth breathers or in other environments where the silicate cement becomes dried out at least on the surface for short periods of time, the difference in shrinkage between the normal and the oil-containing cements is so large that it must be considered. When the reported values on the air-exposed specimens (Table 18, column 5 and Fig. 9) are reduced to correspond with the dimensions of a large restoration (with a maximum linear dimension of about 4 mm. [0.16 inch]), the shrinkage at the end of one hour would amount to 18 microns (0.45 per cent) for the normal cement K, 5 microns (0.13 per cent) with Durosim and 11 microns (0.28 per cent) with petrolatum. This change occurs in one hour and is probably greater in proportion on smaller specimens because they would dry out more thoroughly. Over a long period of time, this change is no doubt large. Measurements with a micrometer caliper (Fig. 9) indicated that the normal and petrolatum-containing cement K shrank about 1.2 per cent; whereas cement K with Durosim had shrunk about 0.6 per cent after three months in air having a relative humidity of 65 per cent at a temperature of 21° C. (70° F.). These are rather large dimensions, amounting to a shrinkage of about 48 microns on the normal and petrolatum-containing cement on a filling 4 mm. long, and about one-half less with the cement containing Durosim. Sometimes, the crevice which develops between the wall of a cavity and the silicate cement filling is so large that it can be seen with the unaided eye. Such a wide crevice could hardly develop if the filling was always coated with saliva. A line 48 microns (almost 0.002 inch) wide is easily visible to the unaided eye. This dimension corresponds to the diameter of a fine human hair.

These results do not seem to be in harmony with the statement on the advertisement that "Durosim prevents shrinkage of the filling material after setting"; nor is there any evidence that a cement containing Durosim will necessarily have "constancy of volume."

Acidity.—The data (Table 18, columns 8 and 9) show that the addition of the oily substances does not significantly change the acidity of a cement mixture. The claim that Durosim tends to neutralize silicate cement mixes appears to be without basis in fact. Certainly if Durosim is used in a cement mix, one should not neglect any of the precautionary steps in pulp protection which are recognized at the present time.

Solubility and Disintegration.—The solubility of cement K was not materially altered by the addition of oils or greases. (Table 18, column 10.) Petrolatum slightly increased the solubility and Durosim slightly decreased it. When Durosim was added to cement A (which had a normal solubility of 3.0 per cent in one week), the solubility was 3.3 per cent. In this instance, the cement containing Durosim was slightly more soluble. The evidence at hand seems to refute the advertised statement: "In practice Durosim

gives: 1.———: 2. Constancy: By essentially reducing solubility. Durosim assures a constant hardness and long life of the filling."

Opacity.—The opacity of a silicate cement is considerably increased by exposure to air. When the oily materials were used with the cement, the opacity was increased when the cement was exposed to air. This effect is shown when disks of cement K with and without oils are examined over a black and white background. (Fig. 8.)

Measurements of specimens which were immersed in water after their initial time of setting are shown in Table 18, column 11. All of the specimens were made from Shade No. 1 so that the data would be comparable. The addition of the petrolatum increased the opacity considerably. The addition of Durosim had very little effect.

The data (Table 18) appear to indicate that the addition of oils or greases to a silicate cement does not materially improve it. The use of oily substances in a silicate cement should be considered as in the experimental stage. Additional data on this question should come from closely controlled clinical tests.

TENTATIVE SPECIFICATIONS

The foregoing work was used as a foundation in the formulation of a tentative specification for dental silicate cement. A tentative draft of the proposed specification was forwarded to dental schools, manufacturers of silicate cement and members of the Research Commission for their criticisms and suggestions. The methods of testing which are incorporated in this specification were designed to subject the material to average service conditions and not to the most favorable conditions. For instance, the powder: liquid ratio required by the specification is not necessarily the best one nor the one prescribed by the manufacturer, but represents the average mixing consistency used by a large group of practicing dentists who cooperated with the Research Commission in this investigation.

AMERICAN DENTAL ASSOCIATION TENTATIVE SPECIFICATON NO. 9 FOR DENTAL SILICATE CEMENT (EFFECTIVE JULY 1, 1938)

A General Specification.

This specification is for dental cement which is to be used for restorations primarily in the anterior teeth.

B. Types.

Only one type of cement is specified.

C. Material.

C-1. The cement shall consist of a powder and a liquid which when mixed in the usual dental manner will harden or set and yield a satisfactory restoration.

C-2. The powder and liquid shall be uniform and free from poisonous foreign materials.

C-3. Shades for the set cement shall be specified by the purchaser.

D. General Requirements.

D-1. The liquid shall be free from cloudiness, precipitates, deposits or sediment.

D-2. Cements when spatulated in the usual dental manner shall not:

D-2a. Form lumps or granules.

D-2b. Evolve gas.

D-2c. Discolor tooth structures after insertion in a tooth.

E. Detail Requirements.

E-1. Time of setting. The time of setting shall not be less than three nor more than eight minutes.

E-2. Ultimate compressive strength. The ultimate compressive strength shall be more than 1260 kg. per square centimeter (approximately 18,000 pounds per square inch) for specimens crushed seven days after mixing.

E-3. Opacity. The opacity represented by the contrast ratio $C_{0.10}$ shall not be less than 0.35 nor more than 0.55. The contrast ratio ($C_{0.10}$) is the ratio between the daylight apparent reflectance of the cement specimen (1 mm. in thickness) when backed by a black backing and the daylight apparent reflectance of the specimen when backed by a white backing having a daylight apparent reflectance of 70 per cent relative to magnesium oxide (MgO).

E-4. Solubility and disintegration. The solu-

bility and disintegration of the cement shall be less than 2.0 per cent by weight when immersed for seven days in distilled water at 37° C. (99° F.).

E-5. Arsenic content. The water soluble arsenic content of the mixed cement shall not exceed one part in 500,000 (0.0002 per cent by weight).

F. Methods of Inspection and Test.

F-1. Preparation of test specimens. The preparation of the test specimens shall be conducted at a temperature between 18 and 24° C. (64 and 75° F.) and at a relative humidity between 55 and 75 per cent. The powder:liquid ratio shall be determined by the consistency test. The mixing technics employed in the preparation of all test specimens shall be according to the directions which are in the packages of the cement, except that the temperature and humidity may vary within the foregoing limits.

All apparatus and instruments shall be clean, dry and free from particles of hardened cement.

F-2. Testing consistency. One type of apparatus for measuring consistency is shown in Figure 2. This apparatus consists of two flat glass plates, a weight and a glass tube (inside diameter approximately 10 mm. [0.39 in.]) which will deliver 0.5 cc. of mixed cement. The combined weight of the top plate and the weight shall be 2,500 gm. (5.51 pounds).

F-2a. Trial amounts of powder shall be mixed with 0.4 cc. of liquid. Then 0.5 cc. of mixed but unset cement shall be delivered from the glass tube on a flat glass plate. Two minutes after the mix is started, another glass plate (weighing approximately 20 gm.) and the additional weight shall be carefully placed on the soft cement. Trials shall be made until the average of the major and minor diameters of the slumped mass of cement is 25 ± 1 mm. (0.98 inch) ten minutes after starting the mix. The average weight of powder used in three such determinations shall be the amount of powder (combined with 0.4 cc. of liquid) necessary to produce a mix of standard consistency.

G. Time of Setting.

G-1. A ring 5 mm. (0.2 inch) high and 10 mm. (0.4 inch) in diameter shall be placed on a flat plate and filled with cement of standard consistency. Two minutes after starting the mix, the specimen shall be transferred to an atmosphere of 100 per cent relative humidity at 37° C. (99° F.). A standard Gillmore needle, weighing 454 gm. (1 pound) and having an end 1.06 mm. (0.0417 inch) in diameter, shall be lowered vertically until the surface of the cement is touched. This shall be repeated at frequent intervals. The time of setting is the number of minutes elapsed from the starting of the mix to the time when the needle fails to make a perceptible circle on the surface of the specimen. The setting time shall be reported to the nearest minute.

H. Ultimate Compressive Strength.

H-1. A cylindrical mold 12 mm. (0.472 inch) high and 6 mm. (0.236 inch) in diameter shall be placed on a flat plate and slightly overfilled with cement of standard consistency. A second flat plate shall be pressed on top of the mold. The molds shall be made of hard rubber, glass or other substance which will not react with the cement. Three minutes after starting the mix, the molds shall be transferred to an atmosphere of 100 per cent relative humidity at 37° C. (99° F.). One hour later, the specimens shall be immersed in distilled water at room temperature.

H-2. The ends of the cylinder shall be surfaced plane at right angles to the axis. The ends of the specimens may be ground flat by the use of a small amount of carborundum powder (200 mesh) and water. The molds containing the specimens shall be drawn back and forth across a glass plate coated with the abrasive and water. They shall be rotated about one fourth turn every few strokes. The test specimens shall be kept wet during the grinding and until after crushing. The machine used in crushing the test specimens shall be operated at a rate of speed which will move the crushing head 0.25 mm. (0.01 inch) a minute.

H-3. The value for compressive strength shall be reported as the average of three or more from a lot of five specimens and shall be rounded off to the nearest 10 kg. per square centimeter. If the values for individual specimens fall more than 15 per cent below the average, they shall be discarded and the average of the remaining specimens shall be reported. In case more than two of the specimens are eliminated, the test shall be repeated.

I. Opacity.

I-1. A sufficient amount of cement of standard testing consistency shall be pressed between two flat glass plates to form a disk of

cement approximately 3 cm. (1.2 inch) in diameter and 1 mm. ±0.025 mm. (0.039 ±0.001 inch) thick. Three minutes after the mix is started, the plates and cement shall be stored for one hour in an atmosphere having a relative humidity of 100 per cent at 37° C. (99°F.). The specimen shall then be removed from the plates and stored for one week in distilled water at 37° C. (99° F.).

I-2. A comparison of the opacities of the cement specimen and two opal glass standards with $C_{0.70}$ values of 0.35 and 0.55 respectively shall be made by placing them (specimen and standards) against a variegated black and white background. A film of distilled water shall cover the cement specimens and the standards and also the space between them and the black and white backing during observations. In comparing the opacity ($C_{0.70}$) of a cement with that of a glass standard, the uncertainty should not exceed ±0.02. If the opacity of the specimen is between the opacities of the standards, the cement complies with this requirement.

J. Solubility and Disintegration.

J-1. The disintegration of a cement is a measure of the erosion plus the extraction of soluble material from the cement by the action of water.

J-2. One-half cubic centimeter of cement of standard consistency shall be pressed between two flat plates until the specimen is 20 mm. (0.79 inch) in diameter. A piece of fine platinum wire placed in the soft cement as the specimens are formed provides a convenient means of holding the specimens. Three minutes after the mix is started, the plates and cement shall be placed in an oven at 37° C. (99° F.) in a relative humidity of 100 per cent and left for one hour.

J-3. After one hour, the specimens shall be withdrawn from the oven and two specimens shall be placed in each tarred weighing bottle and weighed. The combined weight of the two specimens and the weighing bottle, less the weight of the weighing bottle and the platinum wire, shall be taken as the weight of the specimens of cement. The specimens shall immediately be submerged by pouring 50 cc. of distilled water into the weighing bottle, which shall be stored for seven days at 37° C. (99° F.). The specimens shall then be removed from the water. There shall be no evidence of crystal growth or extensions from the surface of the specimens. The water shall be evaporated from the weighing bottle at a temperature just below 100° C. (212° F.). The weighing bottle shall then be dried at 149° C. (300° F.) to constant weight. The weighing bottle and contents shall be weighed. The difference between the final weight of the weighing bottle and its initial weight shall be the amount of disintegration. The gain in weight divided by the weight of the specimens times 100 gives the percentage of disintegration. The average of duplicate tests (two weighing bottles containing two specimens each) shall be reported to the nearest 0.1 per cent.

K. Arsenic Content.

K-1. One gram of hardened cement, powdered to pass a No. 200 sieve, shall be digested in 100 cc. of distilled water on a steam bath for one hour. The filtrate shall

SUMMARY OF DETAIL REQUIREMENTS OF A.D.A. SPECIFICATION NO. 9 FOR DENTAL SILICATE CEMENT

Consistency of Mix	Time of Setting at 37°C. (99°F.)		Ultimate Compressive Strength	Opacity		Solubility and Disintegration	Arsenic Content
	Minimum	Maximum	Minimum	Minimum	Maximum	Maximum	Maximum
	Minutes	Minutes	7 Days	$C_{0.70}$		7 Days	Percentage by Weight
Disk 25 ± 1 mm. in diameter	3	8	Kg./Cm.² 1,260 (Lbs./In.²) (18,000)	0.35	0.55	Percentage by weight 2.0	0.0002 (1 part in 500,000)

be used in the test for water-soluble arsenic.

K-2. The test for arsenic shall conform to that designated by the American Chemical Society recommended specification for reagent phosphoric acid. *(Indus. & Eng. Chem.*, 19:1369, December 1927.) For detailed description of test, see Hillebrand and Lundell: Applied Inorganic Analysis. New York: John Wiley & Sons, 1929, p. 217.

L. Packaging.

L-1. The cement powder and liquid shall be supplied in properly stoppered glass containers. The net weight of the powder shall be indicated on the container. The liquid shall be supplied in an amount 20 per cent in excess of that necessary to combine with the total amount of powder when mixed to testing consistency.

L-2. Adequate and accurate instructions for proportioning and manipulation shall accompany each package. These instructions shall include the temperature of the slab, the powder-liquid ratio, the rate of incorporating the powder and the time of mixing.

L-3. Each package of powder and liquid shall be marked with a serial number or a combination of letters and numbers which shall refer to the manufacturer's records for that particular lot or batch of cement powder or liquid.

L-4. The date of manufacture (year and month) shall be indicated on the package as a separate item or as a part of the serial number.

This specification is only a tentative one and will be revised as new materials and additional knowledge become available. It is believed that this body of correlated testing procedure will provide the means whereby a manufacturer can standardize his production methods and investigators can compare different brands of cements and improve those cements now available. The dental profession can use the specification as a qualitative measure of the properties of silicate cements.

SUMMARY

1. Thirteen trade brands of dental silicate cement which are in current use were investigated. Physical and chemical properties having special dental significance were measured by instruments and test methods, which were in many instances designed for this purpose.

2. Cement powders are generally complex aluminosilicates containing calcium, sodium, fluorides, phosphates and sometimes zinc and beryllium, as major constituents. Iron, magnesium, manganese, nickel, lead, copper, lithium and strontium were often present as minor constituents or in traces. Elements present in traces can usually be attributed to the use of impure chemicals in compounding the powder.

The liquids are aqueous solutions of phosphoric acid to which have been added zinc salts and usually aluminum salts.

In many instances, there is a direct correlation between the composition of a cement and its physical properties.

3. Arsenic was present, but in such small proportions and in such a stable insoluble form that there appears to be very little likelihood of the arsenic content being a factor in pulp death.

4. The specimens used in testing were prepared by a closely controlled yet practical technic. It was found that by regulating the powder : liquid ratio, the temperature of the slab and the time of mixing, and by taking precautions to preserve the water content of the cement liquid, reasonably uniform specimens could be prepared. The mixing technic employed in the preparation of test specimens is feasible for use in any dental office.

5. A method of measuring the consistency of the plastic unset cement was devised. All cements were mixed to a standard consistency based upon the average consistency which a large group of practicing dentists were using.

6. The time of setting of each cement was measured under room and oral conditions. Increasing the powder : liquid ratio decreased the time of setting. The rate of addition of powder to the liquid did not materially affect the time of setting. Increasing the temperature of the

slab decreased the time of setting. Lengthening the time of mixing increased the time of setting. Differences in the times of setting of different batches of the same trade brand of cement were noted.

7. The compressive strengths of specimens stored in natural saliva, distilled water and neutral mineral oil were determined. All of the cements (six months old specimens) except one were strongest when immersed in oil and weakest in water. The specimens immersed in saliva were slightly stronger than those immersed in water; which indicated that distilled water was slightly more destructive to the cements than saliva. Decreasing the powder : liquid ratio within reasonable limits did not seriously affect the strength. The compressive strength of the cements increases with time. The maximum strength in water was with one exception obtained at about six months. In fifteen minutes, a cement may reach 40 per cent, and in three hours 60 per cent, of its maximum strength.

8. The solubility and disintegration were measured by noting the losses in weight of disk-shaped specimens when immersed in distilled water. One cement had practically eight times the loss of the least soluble cement.

Powdered human enamel was much less soluble in distilled water than powdered cements.

9. The pH values of solutions of the powders, liquids and mixed cements were determined electrometrically. The powders were with one exception slightly alkaline. The liquids were very acid. The mixed cements had a high initial acidity, but usually at the end of twenty-four hours approached the pH of the distilled water in which they were immersed.

10. The indices of refraction of the cement powder particles which did not contain zinc oxide ranged from 1.47 to 1.60; whereas the indices of the cementing substance or matrix which binds the powder particles together in the cement were 1.45 to 1.48. When the indices of the powder particles and the cementing substance were near to each other, the cement was not very opaque. The index of refraction of dentin was 1.56 $\pm$0.005; of enamel, 1.60.

The opacity of a cement could not be satisfactorily specified by giving the indices of refraction.

11. Photomicrographs of hardened cements show them to consist of particles of powder, the matrix, which amounts to from 20 to 30 per cent of the mass, and air bubbles.

12. The opacity of enamel and dentin were measured. The cements became less opaque with time. During the first twenty-four hours, the opacity decreased rapidly. The darker shades of the cement were more opaque than the lighter shades. The relationship between opacity and thickness is not linear.

A set of glass standards was developed by means of which the opacity of cements can be judged.

13. Silicate cements have a tendency to shrink. All of the cements shrank when the ends of the specimens were securely fastened into the instrument used in measuring dimensional changes. Generally the size and shape of the test specimen or filling and the time at which the specimen comes in contact with water, together with almost any other variable in the mixing technic or environment, affect the dimensional change during setting. Some slow-setting cements, which are usually made with a liquid of low water-content, have a surface expansion on contact with water. Portions of the specimen not in contact with water shrink.

The so-called "mercurochrome test" does not give a true indication of shrinkage or expansion.

Specimens exposed to wetting and drying alternately expanded and shrank.

The powder : liquid ratio affected the dimensional change during setting. The heavier the consistency of mix, the less the shrinkage.

Certain combinations of conditions can cause a large expansion. For instance, if water comes prematurely in contact with a small specimen which has a surface area which is large for its volume, and which was made from a thin consistency mix of a slow-setting cement, the result, in all probability, will be a great expansion.

Dimensional changes of set cement are so greatly affected by small and uncontrollable variations in environment and in mixing and working that it is not feasible for the dentist to attempt to closely control the dimensional change.

14. Silicate cements vary greatly in resistance to dyes. The cements which stained the least did not necessarily have superior physical properties.

15. Only on one cement was the temperature rise on setting probably great enough to injure the pulp.

16. The admixture of oils and greases in cement mixes decreased the compressive strength, usually decreased the shrinkage in air and slightly decreased the shrinkage in water. The setting time, solubility and distintegration, acidity and opacity were not seriously affected. The use of oils or greases in a cement mix should be considered only as an experimental procedure at the present time.

17. Some cements darkened badly when exposed to hydrogen sulfide. Other cements were just noticeably affected. It it believed that the darkening was caused by the presence of contaminating elements which form dark colored sulfides.

18. Measurements of indentation hardness were made on enamel, dentin and the cements. Enamel was much harder than the cements. The cements had the same order of indentation hardness as dentin.

19. The temperature at which a mix is made greatly affects the consistency. The effect of humidity is comparatively slight, if the mix is made immediately after the liquid is placed upon the slab.

20. When a cement is exposed to water before setting sufficiently, its surface area expands and becomes soft, porous and opaque.

21. The cement liquids lose water in dry air and absorb water in moist air. If the water content of a cement liquid is changed, the cement made from it will usually not set properly. A loss of water by a liquid resulted in a slower-setting cement than normal; whereas absorption of water by the liquid caused acceleration of the setting time.

The composition of the liquids remained constant in an atmosphere having a humidity with which the liquids were in equilibrium.

22. Increasing the powder : liquid ratio decreased the time of setting, increased the compressive strength and decreased solubility, disintegration and shrinkage, but did not appreciably affect the opacity and acidity.

23. The properties of a cement were often found to vary from batch to batch; which indicates that different batches of the same trade brand of powder and liquid are sometimes not uniform.

24. A tentative specification for dental silicate cements is recommended. This specification has definite requirements or limitations for consistency of mix, time of setting, compressive strength, opacity, solubility and disintegration and arsenic content. It is believed that this specification is a suitable standard by which to judge the quality of a silicate cement.

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HEREDITY IN RELATION TO MALOCCLUSION

By WALTER HYDE, D.D.S., Minneapolis, Minn.

ANY extended study of etiology in malocclusion always leaves, when the well-known and readily recognized causes are listed, a certain residue of unexplained cases; cases that apparently have intrinsic factors, some of which most certainly may be considered hereditary.

It is now a matter of common knowledge that all sorts of characteristics, all manifestations of life, are subject to the influence of heredity. Structural characteristics, internal and external, color, form, size, chemical properties, physiologic function, the senses and behavior are all influenced.

Arriving at such a point, the inquiring orthodontist has an inspiration and says to himself: "As to this matter of heredity, I shall make inquiry of the modern geneticist, who, I happen to know, has in the past twenty-five years, or thereabout, accumulated a great mass of correlated and well-established knowledge of the laws of inheritance."

Here, however, a curious situation comes to light. The authority on genetics replies that he does, indeed, have such knowledge, [1, 2] but it does not include, to any great extent, observation on teeth. That, he says to the orthodontist, is *your* field. This situation becomes still more striking when we consider that, in general, in the organic world, the teeth of men and animals have been the most enduring of all anatomic structures, a very large part of the knowledge of early man being based on evidence supplied by teeth. It seems, therefore, that if the orthodontist is to have any satisfactory knowledge of heredity, as applied to orthodontic problems, he must accumulate it for himself.

This is a matter of some importance because there will, if our contention that heredity does play a part in many cases is correct, always be some uncertainty as to treatment when the etiology is obscure. Some orthodontists,[3,4] because of this obscurity, are inclined to minimize the influence of hereditary factors, others take refuge in the statement that these things are hopelessly complex.[4] I prefer, however, to agree with Morgan, who says, "That the fundamental aspects of heredity should have turned out to be so extraordinarily simple supports us in the hope that Nature may, after all, be entirely approachable. Her much advised inscrutability has once more been found to be an illusion due to our ignorance."[5]

The present knowledge of heredity rests upon two kinds of evidence (1) cytologic, *i.e.*, what can actually be seen of the mechanism under the microscope, and (2) that of controlled breeding experiments. Application of such knowledge to human orthodontic problems presents grave difficulties,[6] but constitutes a most potent argument for the great value to come ultimately out of careful observations and well-kept and complete records, including whenever possible as much family history as can be secured.

Before we can hope to have much appreciation of heredity, we must have clearly in mind the mechanism by which it operates and must also divest ourselves of some of the older notions that are still quite commonly held. For instance, many

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of us are still inclined to think that if a child has malocclusion, the condition must be inherited directly from the mother or the father because "like produces like." Actually, there is much more to it than this; for we know that differences are just as easily inherited as likenesses and that parents who appear normal may carry hidden inheritable defects and that others with marked defects may have normal children. What any individual is depends on the nature of the hereditary elements—the genes—that enter into combination in his make-up and how they react to their environment.

We must train ourselves not to be too much influenced by what the parents say concerning family inheritance; for the mother usually thinks the children have their father's defects and the father thinks the mother's family has provided any undesirable qualities.

Fig. 1.—Arrangement of genes in genetic system. One string *(P)* comes from the father, the other *(M)* from the mother. Thus, the genes themselves are in pairs, one member of each pair from the father, one from the mother. The genes showing no mottling in the drawing are to be conceived as defective. (After Jennings.)

MECHANISM OF INHERITANCE

Let us now give attention to this mechanism of inheritance that we may be better prepared to consider such orthodontic problems as may be affected by heredity or that our interest may be aroused enough to make us more observant in the future.

The cellular structure of all living tissue is well known. Morgan says, "One of the most secure generalizations in modern work on the cell is that every cell of every individual, plant or animal, contains a constant number of self-perpetuating bodies, chromosomes, half of which are traceable to the father and half to the mother."[5] Detailed study shows that these chromosomes are always in pairs. Theoretically, they consist of many separate and distinct units—the genes—and might be represented in this form. (Fig. 1.) Those without shading are considered defective. In the summer of 1935, Calvin Bridges actually succeeded in producing photomicrographs that showed the structure of the chromosomes in the salivary glands of the fruit fly.

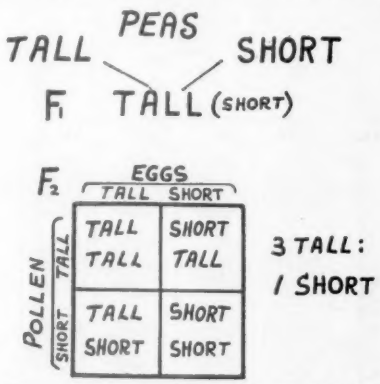

Fig. 2.—Diagram illustrating the fact that when tall and short peas are crossed, all the first generation have the dominant characteristics and are tall, and when members of the first generation are inbred, the offspring are in the proportion of three tall to one short.

In ordinary mitosis, each chromosome splits longitudinally, forming the daughter cells. Each receives one-half of every parent chromosome, and, in this manner,

the number is constant in all somatic cells. When the gamete-producing cells begin to divide, there is no splitting of the chromosome. Instead, one member of each pair passes bodily, apparently at random, into the new cell. Each genetic cell will then have but half as many chromosomes as the normal number. It is only when two such cells unite to form a zygote that the normal number for the species is restored.

A recital of these facts might suggest

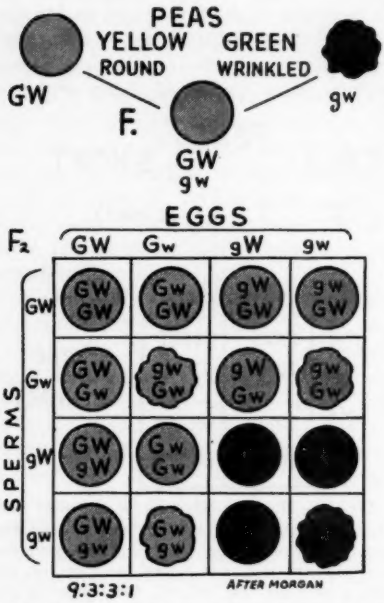

Fig. 3.—Diagram illustrating the principle that when two dominants are crossed with two recessives, the first generation are all like the dominant parent, and when inbred, the second generation presents four types in the ratio 9:3:3:1. Capital letters refer to the dominant characteristics.

that the chromosomes are themselves the units of inheritance. This is not the case, however, as there are a very great many more inherited characteristics in any species than the number of chromosomes. The number is definite and usually not great. For example, the fruit fly has four pairs, the pea seven, man twenty-four and the horse nineteen. All the available evidence leads to the conclusion that the genes are located in the chromosomes and that their segregation is the result of the distribution of the chromosomes in the formation of the genetic cells.

This gives a satisfactory explanation of Mendel's famous experiment in segregation of dominant and recessive characteristics. He crossed tall and short peas and all the first generation were tall, exactly like the dominant parent in appearance; but when inbred, the second generation

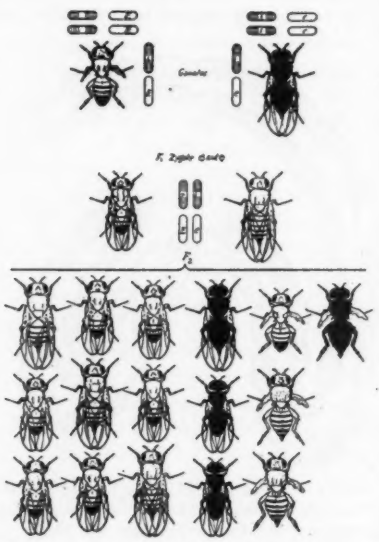

Fig. 4.—Crossing of fruit fly with gray vestigial wings with one with long ebony wings. In the second generation, there will be nine with long gray wings, three with long ebony wings, three with gray vestigial wings and one with ebony vestigial wings.

was always found to occur in the proportion of three tall to one short. (Fig. 2.) The trait of tallness is dominant over shortness.

The essential part of this matter is that the hereditary elements which combine to reproduce the hybrid are not themselves combined, nor do they suffer any change,

but reappear when the germ cells are matured.

The hybrid is by no means always like one parent. Red and white four o'clocks, when crossed, give all pink flowers in the first generation and one red, two pink and one white in the second. This is a case where neither character is completely dominant. We shall return presently to further consideration of dominance.

The evidence for the free assortment of characters is interesting. When two dominants are crossed with two recessives, the first generation are all like the dominant parent, but the second generation presents four types in the ratio 9:3:3:1. (Fig. 3.) If a yellow round pea (both characters being dominant) is crossed with a pea having the recessive characters, green wrinkled, all of the first filial generation will be yellow and round, but they will contain the hereditary units for green, g, and for wrinkled, w, as well as the characters for yellow, G, and round, W. Four types of eggs and four types of sperm are formed, which, uniting at random, will produce nine yellow round; three yellow wrinkled; three green round, and one green wrinkled. That this is a general rule is proved by further experiments. (Fig. 4.) If a gray vestigial winged fruit fly is crossed with an ebony fly with long wings, the second generation will have the proportion nine long winged gray; three long winged ebony; three gray with vestigial wings, and one ebony with vestigial wings. Another illustration of this is obtained from mice. There is a type of mouse called "albino waltzer" because of lack of color and peculiar gait. When it is bred with a gray runner, the proportions in the second generation are the same as above, with "albino waltzers" as recessives.

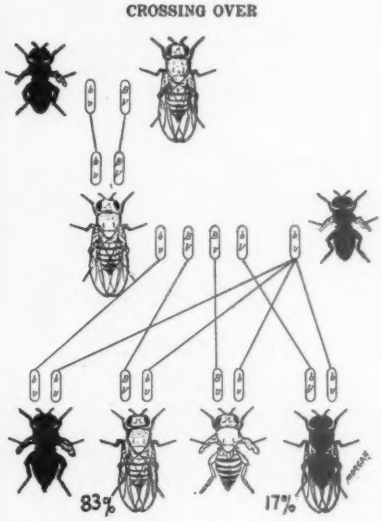

Fig. 5.—Crossing of female fruit fly with long wings and gray body, the daughter of a black male with vestigial wings and a mother with long wings and gray body. Seventeen per cent of the offspring will have crossed characteristics.

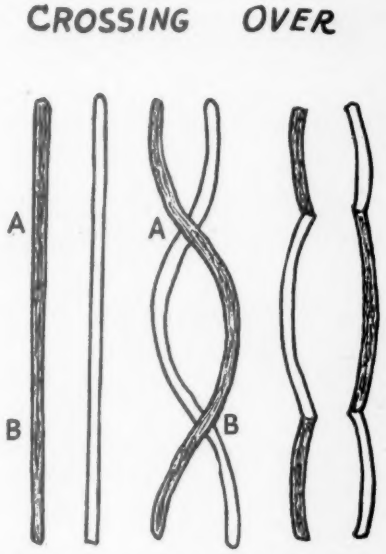

Fig. 6.—Diagram showing how chromosomes in contact at A and B separate so that the genes between these points are carried across to the other chromosomes.

In a chart showing the distribution of three dominants, the proportions will be 27 :9 :9 :9 :3 :3 :3 :1.

If each chromosome is composed of many genes, as segregation and free assortment indicate, we would expect that those in any one chromosome would be distributed as a group and the characters they represent would occur together. This is exactly what happens, constituting the phenomenon called "linkage." Many instances of this kind are known.[7]

Many times, however, characteristics are distributed in a manner that seems to be entirely out of harmony with Mendel's findings. These cases are, on further investigation, found to be the result of an interchange of parts by synaptic chromosomes and is called "crossing over." (Fig. 5.) If a female fruit fly with long

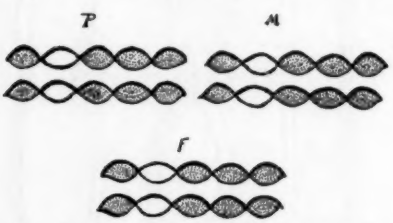

Fig. 7.—Illustration of case in which father *(P)*, having two genes in second pair defective, is himself defective. The mother *(M)* is normal. The child *(F)* receives one set of genes from each parent. It therefore has at least one normal gene in each pair and is not defective.

wings and gray body, the daughter of a black male with vestigial wings and a mother with long wings and gray color, is crossed back to a male with vestigial wings and black body, 17 per cent of the offspring will have crossed characteristics.

These phenomena can be expressed by numerical laws and are just as definite as those discovered by Mendel and in harmony with them. Crossing over (Fig. 6) is a phenomenon that has made possible great advances in the knowledge of the constitution of the chromosomes. It gives evidence of the linear arrangement of the genes and has made it possible to actually make maps of this arrangement in the fruit fly.

This linear order of the genes becomes of great interest. Each gene or group of genes has its regular place in the line and will always be found in position (with due allowance for crossing over). The different pairs of genes have different functions in development, but the two members of the pair have the same functions, though they may operate in a somewhat diverse manner. Actually, it seems that they carry on a kind of conflict and the stronger prevails, determining the characteristic. This is the dominance previously mentioned. For example, a gene from a brown-eyed person may be

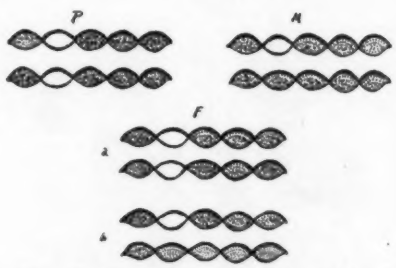

Fig. 8.—Illustration of case in which one parent *(P)* has two defective genes in one pair, the other *(M)* having one defective gene in same pair. Some of the children receive two defective genes in one pair and are therefore defective. Others with but one defective gene in that pair will not be defective.

stronger than one from a blue-eyed person. The stronger gene, carrying development farther, lays down more pigment and the new individual has brown eyes. This is complete dominance, as in the case of the tall peas.

The weaker gene may be merely recessive or actually defective. As a defective condition is usually the result of failure to carry out developmental processes fully, most defects are recessive[8]; which is a most important consideration for any species, as it makes possible the breeding

out of defects. Suppose a defective gene tends to produce laziness, stupidity or feeble-mindedness. A parent with two such defective genes (Fig. 7) will himself be defective so that he is personally lazy, stupid or feeble-minded. He may, however, have normal children by mating with another who is without defect. If, however, the latter parent has one defective gene in this second pair (Fig. 8), there will be two kinds of children—one defective, one normal.

When both parents have one defective gene in a pair, there are four possible combinations (Fig. 9), making three types: normal, normal carriers of the defect and defectives. The father may have both genes defective in the second pair (Fig. 10) and the mother both in the fourth pair. The offspring have no pair in which both genes are defective and are, therefore, normal. When both parents have both genes defective in the same pair (Fig. 11), all the offspring will be defective. Although positive evidence is scanty and controlled breeding but a remote possibility, it seems perfectly logical to conclude that defective inheritance can affect the human teeth and jaws just as it does other characteristics.

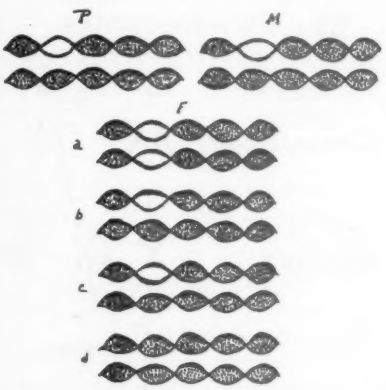

Fig. 9.—Illustration of case in which parents having one defective gene each in the same pair are normal, but may have children with four combinations: *a*, defective; *b*, *c*, normal but carrying the defective genes, or *d*, normal.

INHERITANCE OF SEX

The inheritance of sex is interesting and furnishes the key to many of the puzzles of heredity. It was early discovered that certain individuals at the very beginning of their existence had an odd chromosome, called the X chromosome, or, as in the case of the fruit fly, one pair of chromosomes that were not alike, one being called the Y. In the fruit fly, the individual with the Y proved to be a male and the one with a pair of X's a female. (Fig. 12.) If this observation is correct, we should be able to find certain inherited characteristics that are passed exclusively from mother to son because a son always gets his X chromosome from his mother, never from his father. This is exactly what happens. If a female fruit fly (Fig. 13) with white eyes (two defective X chromosomes) is crossed with a male with red (normal) eyes, the daughters, having two X's, one from the father being normal, will have red eyes like the father. The sons having but one X, and that defective, from the mother will have white eyes. The normal X, for red eyes, from the father is dominant. This type of transmission is called sex linked or sex limited.

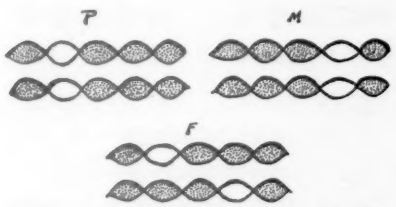

Fig. 10.—Illustration of case in which father *(P)*, having both genes defective in the second pair, and mother *(M)* having both genes defective in the fourth pair, are defective. The offspring has no pair in which both genes are defective and is therefore normal.

Does this kind of inheritance occur in regard to human traits? It does indeed.[9] A number of such traits are known, in-

cluding hemophilia and color blindness. (Fig. 14.) When a color-blind man is mated with a normal woman, the defect is transmitted through the daughters and appears in half the grandsons, the defect being in one X chromosome.

If a color-blind woman mates with a normal man, the defect is present in all the sons and the daughters are normal. In the second generation, with the type of mating shown, half the granddaughters and half the grandsons will have the defect.

ENVIRONMENT AND HEREDITY

Any discussion of this kind would be incomplete without some reference to environment in relation to heredity. To many people, heredity and environment are regarded as separate forces struggling

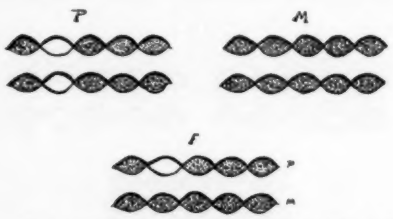

Fig. 11.—Illustration of case in which both parents have both genes in the same pair defective, the offspring then being defective.

for supremacy in trying to determine the character of the individual. For years, which was the more important, heredity or environment, was earnestly debated. Today, geneticists smile at the old theories.

Characteristics of any individual cannot be divided in two distinct classes, one the result of heredity and the other the result of environment. All characteristics are the products of development. Development is an interaction between the inherited material and other things, one of which is environment. It is undoubtedly true that inherited genes produce certain characteristics; but environment is capable of modifying characteristics, so that it might be said that most characteristics are both hereditary and environmental.

For example, Emerson[10] found that different colors in maize are hereditary. In a sunny field, some are red and some are green, as to flowers, leaves, etc. Cultivated separately, they breed true. If crossed, the color is inherited in a typical mendelian manner, which shows that color is due to genes. Color, however, can be shown to depend also on environment. The genes that produce red do so only in sunlight. If maize is grown in the shade, the color is green. So two plants with the same genes may be two colors. But two other plants grown in the sun may be red

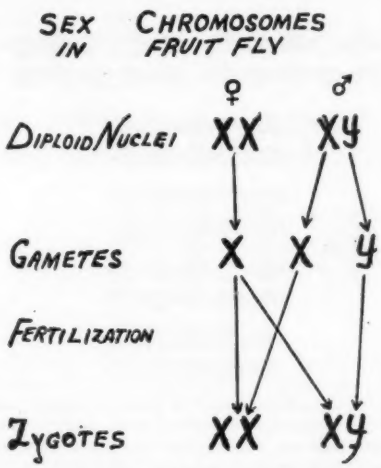

Fig. 12.—Sex in fruit fly. The individual having the odd chromosome (Y) proved to be a male, which produced two types of gamete. The female produces but one type.

and green, the differences being due to the genes they inherited. Here, we have difference produced in one case by environment and in the other by inheritance.

Another illustration of the interaction of genes and environment is shown in the production of giantism among the fruit flies. In certain flies, a modified gene in the X chromosome causes them, when no other type X chromosome is present, to

grow to about twice the size of the ordinary fly. This increase in size, however, takes place only when the individual is well fed during a certain period in the larval stage. Individuals without the gene do not become giants no matter how well fed; those bearing the gene only when well fed. Here, then, is a specific character that requires a special environment acting on a special inheritance.

Naturally, the question arises, "Are there characters that cannot be changed

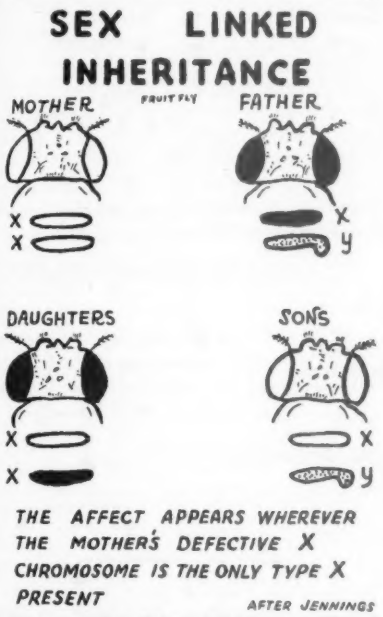

Fig. 13.—Sex linked inheritance. If a female fruit fly with white eyes (two defective X chromosomes) is mated with a male with red eyes (normal), the daughters, having one normal X chromosome, will have red eyes. The sons, having only a defective X chromosome, will have white eyes.

by environment?" There certainly are such. For example, the color of the eyes is known definitely to be the result of heredity and to be uneffected by environment.[8] Whether ways may be found sometime to alter such characters is another question.

HEREDITARY DENTAL CONDITIONS

Having taken a look at the mechanism of heredity and having observed that there exists a uniformity as to its operation among all living organisms, plants, insects, animals and man, let us now examine some of the recorded evidence in regard to human dental conditions.

The best observations by the geneticist have been made in rapid growing organisms where generations mature quickly and breeding can be controlled. Obviously, these are conditions that do not obtain where humanity is the subject. We look for controlled mating only in the distant future and will have to be content yet awhile with the more obvious and easily made observations.

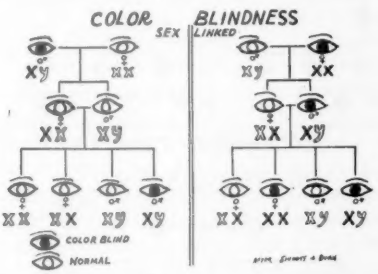

Fig. 14.—Inheritance of color blindness. When a color blind man is mated with a normal woman, the defect is transmitted through the daughters and appears in half the sons. When a normal man is mated with a color blind woman, the daughters will be normal and the sons color blind. In the second generation in this type of mating, half the granddaughters and half the grandsons will have the defect.

That there are to be found in families definite similarities as to form and qualities will be so apparent to all dental practitioners of experience, I think, that no objection will be made to such a statement. That such similarities exist in regard to malocclusion has probably been observed by all orthodontists. For our present purpose, however, we want something more definite and far-reaching than just the observation that the boy patient

has "crooked teeth" like his mother's. It is but natural that the more unusual and striking variations from normal should be most easily observed; hence, we would expect to find such manifestations as transpositions, the presence of fused and supernumerary teeth, malformations and absence of teeth among the records. This is exactly what happens.

It is not my purpose to make an extended recital of such cases, but to refer only to a sufficient number to verify what I have said. A. M. Crosman[11] reports the

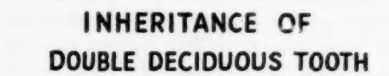

Fig. 15.—Inheritance of double incisors through four generations and an enamel defect through three generations.

case of a young man whose bicuspids were mesial to his cuspids, the same condition being found in the mouth of his father and also in the mouths of two cousins, one of each sex. The same writer refers to a peg lateral incisor that was observed in a mother and in both her son and her daughter.

Moody and Montgomery[12] report the occurrence of "double incisors" in three families. Figure 15 shows one family through four generations, all those affected being females. The same observers report teeth with so-called "sclerosed transparent enamel" through three generations. (Fig. 15.)

R. L. Webster[13] reports the occurrence of a supernumerary tooth in one of twins (both girls) and in a younger brother and the mother. It would appear that this is definitely hereditary and would further suggest that the twins are probably not identical though of the same sex.

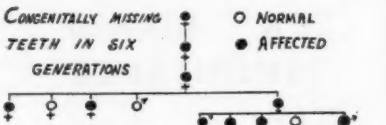

Fig. 16.—Inheritance of missing teeth through five generations.

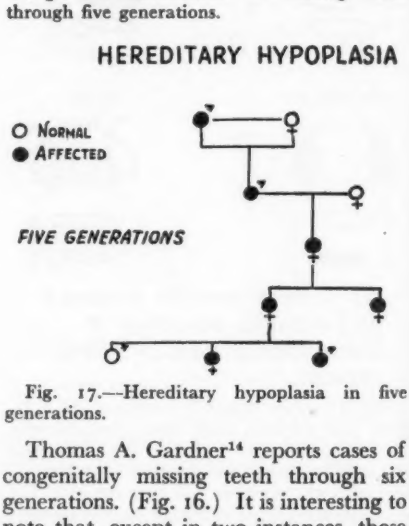

Fig. 17.—Hereditary hypoplasia in five generations.

Thomas A. Gardner[14] reports cases of congenitally missing teeth through six generations. (Fig. 16.) It is interesting to note that, except in two instances, those affected and transmitting the defect were females. I presume that every one of you can recall cases of teeth missing in more than one member of a family.

J. H. Gibbs[15] reports the case of two brothers with a total absence of teeth, other children in the family being normal. Neither boy could perspire. It is

interesting that these conditions, anhydrosis and anodontia, have been reported as associated by others, it being even said that there is in India a race of toothless men who never perspire.[16] The famous Negro Tom Dawking was of this type.[17]

Press dispatches from Omaha, Nebr., as recent as December 13 of last year, report a case of anhydrosis in a fourteen-year-old boy who has no permanent teeth and only six deciduous teeth. Other epidermal appendages are scant or entirely lacking. He has no eyebrows nor eyelashes.

Wilson and Steinbrecher[18] report cases of hypoplasia manifest in five generations. (Fig. 17.) "The crowns of all the teeth were dark bluish gray homogeneously (not mottled enamel)." In the first two generations, the occurrence was in the males; in the next two, in females, and in the fifth generation, in both a male and a female.

Studies on identical twins are most valuable as to evidence of the influence of heredity. Bachrach and Young[19] made a study of 301 pairs of twins, 130 of whom were described as identical. They found in the identical twins a closer affinity as to (1) tooth eruption, (2) hypoplasia in both and (3) the occurrence of the normal as to occlusion and the condition of the gums. Only in the incidence of caries were they less alike than the fraternal twins.

Are there some worth while conclusions to be made from this amount of consideration of this interesting subject? It seems probable.

1. When all sorts of manifestations of life are shown to be subject to heredity, it would be unreasonable to assume that the teeth and jaws are exceptions.

2. If some active force in environment is preventing a full realization of inherited possibilities, it is certainly our duty to remove such a handicap. That some cases of malocclusion unquestionably fall within this category will readily occur to all of you.

3. The general understanding of heredity has come about through carefully controlled experiments and the keeping of complete records. Though the first of these is not possible for us, the second is. If all present day orthodontists will keep adequate records, including just as much family history as possible, the students of the future will not be compelled to work with the limited material we have today.

It would be well for every one to take note of the fact that there has been established in England a great clearing house for the collection of material bearing on human heredity. The Bureau of Human Heredity, 115 Gower St., London, W.C.I., is collecting evidence having to do with human genetics. It is directed by a council representing medical and scientific societies. It is affiliated with the International Human Heredity Committee, which insures cooperation in areas where research is proceeding. The council is grateful to receive all available material from any source whatever. Evidence of the transmission of human traits and characteristics should be well authenticated and given with all details. All communications are considered confidential. I hope that you will all make a note of the identity of this institution.[20]

4. A further value from well-kept records will be that prompt recognition of definite familial defects of development will forewarn the orthodontist of difficulties ahead and temper his enthusiasm as to the possibilities in those cases that are inherently certain to be failures if too great results are expected.

It is my hope that what I have had to say will make us all more understanding and observant in the future rather than to add to our frequent uncertainty.

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434 La Salle Building.

SURGICAL LESIONS OF THE MOUTH IN RELATION TO THE GENERAL HEALTH

By LAWRENCE CURTIS, D.D.S., M.D., F.A.C.S., Philadelphia, Pa.

WE are thinking and talking more and more today in terms of public health, and it seems pertinent to discuss briefly at this time some of the abnormal conditions in and about the mouth amenable to surgical treatment which have a direct relation to the general health of the individual.

The mouth, along with the nasal passages, is the gateway to the alimentary canal and also to the respiratory tract. The rôle played by the salivary enzymes in the digestion of food needs no consideration here, for we well know of the value of proper mastication and the consequent mixing of the bolus of food and saliva before swallowing. Of late we are learning more about the action of the saliva on bacteria in the mouth, and it has been definitely established that many of the organisms, such as the pneumococcus and the diphtheria bacillus, are curtailed, if not in some cases inhibited, in their action, by normal saliva. Which incidentally raises the question: Is not the use of mouthwashes in many instances to be discouraged because of the possible inhibitory action on the salivary enzymes?

No one will dispute the fact that a good masticatory apparatus is essential to real good health. Therefore, any considerable abnormality in the chewing mechanism must be considered a handicap to the physical well being of the individual and should be corrected, if possible.

MANDIBULAR PROGNATHISM, RETROGNATHISM, AND TRUE ANKYLOSIS OF THE JOINT

The individual with the bull dog lower

(Read before the Section on Oral Surgery, Exodontia and Anesthesia at the Seventy-Ninth Annual Session of the American Dental Association, Atlantic City, N. J., July 14, 1937.)

jaw and marked protrusion and malocclusion has little chance of delivering his food to the stomach in proper condition. The salivary enzymes have had practically no opportunity to do their share of the work in the digestive process, for usually in such cases the food is bolted down as quickly as possible. This deformity, whether it be congenital or acquired, is not pleasant to look upon, and the patient is apt to develop an inferiority complex which, in turn, militates against his general well being.

Then, conversely, we have the individual with the "Andy Gump" chin, sometimes so recessive in character as to portray an almost chinless profile. This deformity may be congenital but more often it is acquired from one or more of many causes, notably, following an osteomyelitis of the lower jaw with loss of bone and failure of new bone formation, or as a result of a bony ankylosis of one or both mandibular joints, from whatever cause. The unfortunate individual can probably chew his food to some extent, more so, possibly, than the person with the prognathous jaw, but neither one of them can bite a piece of bread in two. And the person with the hard-to-find chin is certainly apt to be mentally disturbed over his affliction.

Fortunately, in the majority of cases, much can be done surgically for both of these deformities by dividing both rami horizontally above the mandibular foramina, bringing the mandible forward, or pushing it backward, as the case may be, and then treating it as a bilateral fracture. The individual may thus be given a fairly efficient chewing mechanism, and an inferiority complex may give way, in short order, to normal mental processes.

Then there is the person, usually a child, with a true bony ankylosis, more often confined to one joint. This condition can in most instances be traced to some such disease as scarlet fever at an early age, or to some injury to the joint, as a fracture of the neck of the condyle, or following an infection of the jaw bones. The mandible, becoming fixed, cannot function and thus grow, so the characteristic deformity gradually follows, if nothing is done about it. Strangely enough, the patient usually comes for treatment, not because he is unable to eat properly and not because he is often a poor physical specimen, but because he has a toothache and not much can be done for him with his jaws locked.

Here too, we can usually relieve the sufferer by removing a section of the ramus on the involved side and following this up with active chewing and stretching exercises to prevent, if possible, a secondary union. By removing diseased and misplaced teeth and substituting artificial ones a good masticating apparatus can be afforded the patient. Unfortunately, a good many of these youngsters are not compelled to continue their jaw exercises after operation, and the ankylosis develops again.

PUS-BEARING AREAS

The subject of focal infection has undoubtedly received undue attention, but the fad is losing popularity, and wisely so, but it is merely common sense to say that any pus-producing area about the mouth, whether it be a hidden area in the bone, draining its poisons through the blood and lymph channels, or some more superficial area, which drains freely into the mouth, is not a desirable condition for any one, and should be promptly eradicated.

We do not have time here to consider the interesting subject of root resection, but it is my feeling that many a tooth, involved in a periapical infection, in a selected area and in an apparently healthy individual, can be saved by a proper combination of root-canal therapy and surgery, and it is my practice to frequently employ this means of saving a tooth, with gratifying results.

We find too many residual cysts in the jaw bones with a history of previous ex-

traction of teeth and merely allowing the socket to drain, only to have it become infected and present a foul-smelling, pus-bearing area. We must remember that nearly every cyst of dental origin has some sort of an epithelial lining which must be removed one way or another in order that the area may cease to be a pathological entity.

And, too, something should be done to relieve the large number of people who have in their mouths teeth so loose that they wobble back and forth with each inspiration and expiration. The tissues around these teeth are always diseased. In competent hands these conditions are, of course, properly taken care of by the periodontist or the exodontist, but many people attribute too much value to a tooth which has long since ceased to be a useful servant.

BUCCO-ANTRAL FISTULAE

Diseases of the paranasal sinuses cause all sorts of trouble, but we are interested at this time only in the maxillary sinus, or antrum of Highmore, when infected through an opening into the mouth. You will recall that the maxillary sinus begins to develop about the fourth month of intra-uterine life by an invagination of the lining membrane of the nose from the *hiatus semilunaris* into the body of the maxilla. Therefore, the bacterial flora in the nose and antrum get along peaceably; but once the microorganisms of the mouth gain access to the antrum, a potential infection at once exists. If a bucco-antral opening is made by the removal of a tooth, whether the tooth is diseased or not, or whether or not there is a preexisting infection in the antrum, it is most important, first, never to make that opening any larger for any purpose whatever, and second, to close the opening as soon as possible. It may close itself if left alone, and probably will in most cases where a clean sinus is involved. A flap operation from the palate or buccal mucosa may be required to eventually close the opening, and, as a last resort, if the infection in the sinus is severe and persists in spite of conservative treatment, radical procedure becomes necessary.

Some dentists feel called upon to follow any surgical procedure in the mouth, from a simple extraction on, with some kind of a drain, if there is room to insert one. As far as these bucco-antral fistulae are concerned, it is undesirable to keep gauze or rubber tissue drains in these openings, for not only does their presence cause and keep up a constant reinfection into the sinus from the mouth, but the opening will never close as long as they are there.

The bacterial flora of the mouth belong in the mouth, and nowhere else, except as they may pass on down the alimentary canal. If some one were to bite you and break the skin, the wound should be cauterized with some very powerful chemical, as fuming nitric acid, or the actual cautery. Many a finger has been lost in the past; many a severe infection produced by treating the human bite too lightly. Now we fully realize the importance of keeping the microorganisms of the mouth in their own place. If it becomes necessary to open into the antrum to remove a broken root or some other foreign body, we should go in under a mucoperiosteal flap and through an opening well above the apices of the premolars, then suture the flap tightly, after the work is done, and be sure that there is proper drainage into the nose, not the mouth.

LEUKOPLAKIA AND PRECANCEROUS LESIONS

Cancer in general is apparently on the increase and is being publicized and studied with determined energy. We cannot discuss cancer of the mouth at this time, but I cannot refrain from emphasizing the fact that a great deal of this human scourge can be prevented, and a great many cases cured by early recognition of certain lesions and their proper treatment.

One of the most prevalent precancer-

ous lesions in the mouth is leukoplakia, sometimes spoken of as leukoma, or leukokeratosis, or "smoker's patches." Some claim that leukoplakia is caused entirely from the use of tobacco, but I have seen it in the mouth of a woman who never used tobacco in any form in her life. The most common cause of leukoplakia is the use of tobacco, and the patches are seen most frequently in the mouths of pipe smokers. These men usually hold their pipes in the same position, and there is a constant irritation caused by the warm, concentrated stream of smoke directed to one area on the mucous membrane of the cheek. Leukoplakia may occur in the mouth wherever there is mucous membrane, and the tongue is frequently affected. Other mechanical, chemical and thermal irritants may cause leukoplakia and it is frequently associated with syphilis.

There are certain very definite things to be done in treating leukoplakia, and also certain very definite things that should not be done; the latter, however, are unfortunately happening every day. These white patches are made up of layer upon layer of keratinized epithelium and are perfectly harmless up to a certain point. If, however, the epithelial cells decide to invade the subcutaneous tissues, we then have potential cancer and that is just what we want to prevent.

A great many dentists and physicians feel the need of applying some sort of medication to every lesion in the mouth. This custom is usually harmless, but the worst thing that can be done is to apply any irritant to leukoplakia, such as the x-ray, radium or irritating chemicals. The pernicious habit of daubing these lesions with silver nitrate cannot be too strongly condemned. When we see a patient with leukoplakia and the patches are not far advanced, that is, if they are smooth and soft at the base, gradual discontinuance of the use of tobacco to absolute abstinence, or eliminating any other form of irritation which may be present, will probably prevent any extension of the disease and it may entirely disappear. There is no point in removing one irritant and then applying another. If the lesions become fissured, ulcerated and indurated at the base, then it is necessary to remove them, if possible, and this should be done by excision, followed by cautery or by the cautery alone, depending on conditions. The tissue should always be examined under a microscope and, if found to be malignant, irradiation is in order. Recently it has been pointed out by Geschickter, I believe, that the use of haliver oil with viosterol is often very beneficial in the treatment of early leukoplakia.

All fissures, particularly on the lips and tongue, all ulcers anywhere in the mouth and all growths which persist more than two weeks should be excised and examined under the microscope, especially after the age of thirty-five. Many a potential and existing cancer, too, can thus be nipped in the bud; a cancer prevented or a cancer cured by proper treatment.

In conclusion, strictly speaking, any abnormal lesion about the mouth whether surgical or non-surgical, militates against the general health, and I have pointed out very briefly a few conditions which may be corrected by surgical intervention, wisely directed, to the benefit of the individual and the community as a whole.

255 South 17th Street.

DIETARY FACTORS IN PERIODONTAL DISTURBANCES

By HAROLD J. LEONARD, D.D.S., B.A., New York City

THERE has long been an idea prevalent among many dentists that gingivitis and periodontoclasia are to some extent manifestations of some systemic derangement related to the diet. There are a number of facts which lend support to such a theory. One of the earliest manifestations of scurvy, diet-deficiency disease, is a periodontal disturbance leading to soreness of the gums and loosening of the teeth. People living under primitive dietary conditions have naturally clean teeth and very little gingivitis and periodontoclasia, even in the absence of any mouth care. Wild animals and ranging hunting dogs do not have periodontal disease, whereas many animals in captivity and lap dogs, as they get older, frequently lose their teeth from periodontoclasia. Grieves[1] and others have caused periodontoclasia to develop about the teeth of rats by feeding a deficiency diet. Hanke[2] has freed a large group of children in an orphanage of gingivitis by the simple addition of orange juice to the diet. These and other facts which have appeared from time to time have convinced many dentists that periodontal diseases have an underlying nutritional basis and their treatment should consist in dietary study and corrections.

PATHOLOGY

Before a critical analysis of the available data can be made, it is necessary to understand the pathology of gingivitis and periodontoclasia and other disturbances of the periodontal tissues. Only on a basis of pathology is it possible to appreciate the various avenues by which dietary factors may play their part in periodontal disease.

All evidence indicates that gingivitis and periodontoclasia are inflammatory conditions brought about chiefly by bacterial invasion and infection. Bacteria accumulating against the gingiva irritate the tissue, eventually causing swelling and loosening of it, so that the crevice is opened to deeper penetration. The lining of the crevice in such inflammation produces an exudate from which calculus is deposited on the root surface under the gingival margin. The calculus, being porous and full of bacteria, is highly irritating and tends to cause further and deeper tissue inflammation. Epithelium tends to grow down the root to protect the underlying structures and does so at the expense of connective tissue fibers of the pericementum which have become softened and degenerated by the inflammatory condition. As calculus increases and infectious products accumulate, the epithelium is split to permit deepening of the crevice to form a pocket. When the inflammatory zone reaches the alveolar crest, the bone becomes rarefied and is gradually destroyed. Its lime salts no doubt contribute to the formation of the subgingival calculus. Calculus, once formed on the root surface, is not easily resorbed by the tissues. Its presence tends to cause further and deeper pocket formation, permitting further calculus deposit, until the tooth or teeth are lost. A vicious cycle is es-

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tablished which can be broken only by operative interference to remove the calculus and bacterial accumulations on the tooth surfaces, and by massage to get rid of the bacteria within the tissue, thus permitting normal tissue elements to replace inflammatory ones.

ETIOLOGY

While bacterial accumulations on the tooth surface are important in the etiology of gingivitis and periodontoclasia, other factors also play a part. Mechanical injury is especially important. Arrangement of the teeth such that food can be forcibly impacted under the gingival margin is an important cause of pocket formation and inflammation. Irregularities of position such that teeth are subjected to excessive movements in their sockets during masticatory motions cause mechanical trauma of the pericementum and alveolar bone leading to bone resorption and degenerative changes in the pericementum. Such changes open the way to bacterial invasion and tissue destruction even in the absence of bacterial accumulations or calculus on the teeth. Lack of function leads to diminished blood supply and weakness of tissue which invites bacterial invasion. Lastly, any systemic condition which lowers the tissue resistance barriers to infection is likely to result in bacterial invasion of the gingiva, since this structure, from the time the teeth erupt, is, in the presence of micro-organisms, constantly capable of such invasion if the defenses are broken.

What has been said applies particularly to the gingivitis and periodontoclasia caused by the penetration of ordinary mouth micro-organisms, chiefly *Streptococcus viridans.* Vincent's organisms create a somewhat different picture especially when infection is acute. The production of toxic substances by the growth of these organisms against the tissue leads to rapid surface necrosis, which gives the peculiar progressive ulcerative character to this infection. Otherwise, the principles underlying bacterial invasion and tissue vulnerability apply to these organisms as to the other less virulent mouth organisms.

As the etiology of acute simple stomatitis, that sudden painful swelling and soreness of the gums that sometimes accompanies colds in children and young adults, and subsides as quickly as it comes, is unknown, it will not be discussed in relation to diet. Any discussion of chronic desquamative gingivitis will be omitted since, up to the present, its etiology also is unknown.

DIETARY FACTORS

There are, to my mind, seven conceivable ways in which dietary factors may affect the periodontal structures:

1. The physical consistency of the food and the requirement of prolonged vigorous mastication may have their effects from mechanical cleansing of the teeth and massaging of the gingival and periodontal structures.

2. The consistency of the food may have an effect by leaving a residue of adherent material on or between the teeth which serves as a pabulum for bacterial growth and activity.

3. The use of certain types of food may, in some persons, lead to heavy deposits on the teeth through the salivary secretion or through reverse peristalsis from the stomach and intestines.

4. Poisons, including food poisons, may lower the resistance of the whole body, including the gingivae, to infection.

5. The gingivae may be allergic to certain foods, either directly or after their absorption.

6. Food deficiencies may lower tissue resistance to infection, including the resistance of the gingiva.

7. Food deficiencies may lead to changes in the metabolism of connective tissue and bone which may be evidenced in a weakening or resorption of alveolar bone.

These seven points will be reviewed in some detail.

The effect of physical consistency of food on the periodontal structures is best studied through observations on the Eskimos. These people are notoriously filthy. They never clean the teeth, which consequently become heavily coated with sordes and calculus. The effect of these deposits is to cause gradual gingival recession, which, by old age, may cause the loss of teeth. But, according to Leuman M. Waugh, who has made extensive studies of these people, the Eskimos never have periodontal pockets or periodontoclasia while living on their primitive native diets. These diets consist almost wholly of fried and frozen meats and are so difficult to masticate that the young women are required to prepare the food for the little children by mastication before it is fed to them. As a result of excessive function, the jaws are large and powerful, with regular wide arches, and the alveolar bone is thick and dense. An examination of the dental casts of these people shows the extremely thick and bulging alveolar process about the teeth. The great strength of the alveolar support is indicated by tests made by Dr. Waugh with a gnathodynamometer, an instrument for measuring the crushing strength between molar teeth. Dr. Waugh said that he found the measurements ranging between 200 and 350 pounds and averaging for men 297 pounds. Brekhus,[8] in a study of the biting strength of college athletes, found an average of 128 pounds.

These facts seem to indicate a function of the supporting tissues in the Eskimos so excessive that these structures are immune to deep invasion. Hence, bacterial accumulations sufficient to cause gradual recession of the structures do not lead to pocket formation, which would certainly be expected were these structures less well developed and less vigorously used.

The therapeutic effect of massage in periodontal disease is well recognized. A series of pressures and releases on the infected tissue has the effect of alternately squeezing out stagnant fluids and bringing in fresh blood. This is standard procedure in restoring deeply infected periodontal structures to health. By reason of the diet, the Eskimo accomplishes this massage by his masticatory function, and thus keeps the deeper periodontal tissues free from infection.

The massage function of vigorous mastication from early childhood for the development of well-formed dental arches and ample supporting bone is coming to be recognized by orthodontists. This function is equally important in the maintenance of the supporting structures against bacterial invasion. The time will no doubt soon come when foods will be modified to require masticatory effort instead of being prepared to require little if any chewing.

The use of food that requires prolonged chewing has two more beneficial effects: first, a mechanical cleansing of the teeth and, second, a prolonged period of salivary stimulation. Both of these effects tend to remove bacterial deposits from the teeth. During mastication, coarse fibrous food particles also impinge on the gingival tissues to give them a superficial massage. For these reasons, probably as much as because of nutritional constituents, we find the teeth of primitive folk, those who live close to the land and are obliged to eat coarse, unrefined foods, comparatively free from periodontal disturbances.

It cannot be stated too strongly that the prolonged vigorous mastication required by coarse fibrous food has the effect of developing well-arranged teeth with wide arches and ample supporting bone, and of keeping the deep periodontal structures as well as the gingivae in a good state of function and therefore resistant to bacterial invasion. It also tends to keep the teeth free from the bacterial slime which is the primary source of irritation.

The modern food made up principally of cooked starch and sugar products, so prepared as to require but slight mastication, tends to adhere to the teeth and remain as a fermenting residue on the tooth surfaces. The resultant products of such carbohydrate fermentation are acid, the bacteria lactobacilli. These bacilli are not invaders of living tissue cells, and hence their presence does not lead to periodontal disturbances except as the acid fermentation products are irritating and a narrow margin of gingivitis results. Where this type of gingivitis exists, there is ordinarily cervical caries, but little tendency to pocket formation. This fact has been largely responsible for the theory that pyorrhea and caries do not progress together, a theory which is not generally true.

One of the most important aspects of diet in relation to periodontal disease is the tendency, under certain dietary conditions, for heavy bacterial growth to occur on the teeth. The exact mechanism in this condition has not been established. A few facts give some suggestions regarding it. G. V. Black,[4] in his studies on salivary calculus, found that if he ate heartily of any easily digested foods, then rested afterwards, his teeth became coated with soft deposit. The deposit was protein in nature, globulin to be exact, and it came from the saliva. In his case, the globulin was combined with calcium salts, which remained as calculus after the globulin had been removed by bacterial action. He found that salivary calculus is formed by deposits of what he called calco-globulin, coming from the saliva from one and a half to two hours after excessive eating. He attributed the salivary deposit to an excess of absorbed digestion products in the blood at that time, which spilled over into the saliva. Anything which delayed digestion, such as failure of function or exercise, prevented the excess accumulation. All persons tested did not show the phenomenon. Many persons of delicate health had a flow of globulin in the saliva fairly regularly after eating even though the meals were not excessive. In these cases, however, the calcium salts were absent. By reducing the size of the meals to actual requirements, he and those of his experimental subjects who were troubled with salivary calculus accumulations were freed from this annoyance.

These studies of Black are extremely important to our understanding of the source of materies alba or sordes, with which many of our patients are troubled. The deposit comes from the saliva and is apparently due to some condition in which digestion products accumulate in the blood faster than they can be utilized by the body cells, or stored or broken down into excretion products for elimination by the kidneys. The remedy lies in reducing the size of meals to body requirements or in increasing the amount of indigestible substance, such as cellulose, that digestion and absorption may be delayed. The subject should have many interesting systemic ramifications, but as far as I know, no thorough investigation of it has been made other than that of Black. A statement by Prinz and Greenbaum[5] may have some application in this connection. They say, "We have observed individuals develop a heavily furred tongue while on an 'alkaline' (milk-vegetable) diet and have it disappear on an 'acid' (meat) diet." There may be a relation between this coating and the calco-globulin secretion of Black.

To the dentist interested in periodontal disease, the most important phase of Black's findings is not that regarding the source of salivary calculus, but rather that regarding the globulin flow in the saliva. The accumulation of globulin on the tooth surfaces is, to my mind, one of the most important causes of periodontoclasia. It is the pabulum on which the bacteria capable of invading the tissues can grow in excessive numbers. The products of putrefaction of globulin by mouth organisms are alkaline in reaction,

and are toxic. The result is a chronic penetrating inflammation and infection of the gingiva. It is a type of disturbance difficult to treat unless the patient can be taught a home care technic capable of removing the deposit completely at twice daily intervals. Globulin is an extremely adherent material and is not removed by simple rinsing or light brushing. The regulation of diet when the cause is simple overeating can be accomplished by the dentist. When some fault in metabolism causes these deposits to form on the teeth in persons who eat moderately, the case is one for cooperation between the dentist and a competent physician.

Reverse peristalsis of intestinal contents to the stomach and mouth is probably more common than is supposed. It appears to account for certain cases in which a brownish odorous, very irritating soft deposit forms on the teeth. It is found in certain cases of so-called nervous indigestion and undoubtedly reflects a neurotic tendency. The systemic treatment should probably be psychologic rather than dietary. To the dentist, it offers a real problem, for it is difficult to teach patients who have this trouble a home care technic sufficiently exacting to keep the teeth entirely free of the deposit. Wherever it is not removed, the gingiva quickly becomes swollen, sensitive and hemorrhagic to touch. It may easily be mistaken for Vincent's infection, but absence of tissue surface necrosis and absence of Vincent's organisms prove that it has other causes.

Many people suffer from lack of sufficient fluid intake. Insufficient water intake manifests itself in the mouth early as dry mouth often associated with bad taste and bad breath. The teeth become coated and gingivitis results. The normal daily quota of fluid for the adult is at least 2 quarts, and much more if the weather is warm.

Poisoning of the body tissues, including the periodontal tissues, through food is another conceivable process by which dietary factors may have an effect on these structures. It is well known that mercury, lead and bismuth have a predilection for gingival tissues, especially if gingivitis is present to begin with. It might be advanced that constipation, by liberating toxic substances in the blood, is a cause of periodontoclasia. This idea that constipation causes disturbances in nutrition because of the absorption of toxic products is fairly well discredited at the present time. Alvarez[6] has well shown that the intestinal wall and the liver are amply provided with means for detoxifying any products formed by the digestion or bacterial decomposition of foodstuffs in the intestine. The well-known physiologic effects of fecal retention are now believed to be due to nervous reactions from the presence of fecal masses in the sigmoid flexure and rectum. There is little evidence that toxic products from food, other than in botulism or in the case of food contamination by pathogenic organisms, are a factor in disease.

Exception to this statement occurs in the case of food allergy. Allergy is a condition in which chemical substances other than the normal digestion products find their way into the blood stream or tissues and are broken up by the body cells into toxic products. When these substances are taken in slowly, they are attacked by antibodies, which are formed to combat them, and the toxic substances are liberated and eliminated as they are formed, with no harmful result. A sensitized person is one who has an abundance of antibodies prepared for the offending chemical. When the foreign substance appears after an interval in which antibodies have accumulated, it is immediately attacked by antibodies and the toxic products are swiftly liberated to cause allergic reactions such as hay-fever, asthma, hives and procaine dermatitis. Food allergy is a condition in which certain food products are absorbed without undergoing complete digestion and thus

appear in the blood stream as foreign substances. Most of these are believed to be proteins or slightly split protein derivatives. Shell fish, strawberries and tomatoes are perhaps the most common allergens, but many persons are sensitive to eggs, fish, milk and other common foods.

A possible allergic etiology for gingivitis and periodontoclasia has been advanced by J. C. Healy,[7] who has asserted that the majority of cases of these diseases which he has studied give evidence of such allergic etiology and respond favorably to identification and elimination of or treatment for the offending allergen. His test for allergic etiology consists in making a differential count of blood taken from inflamed gingivae and finding therein a high percentage of eosinophils. In a short series of tests to verify this finding, I failed to find one in which eosinophilia in gingival blood could be demonstrated; nor did studies of the histories disclose any facts which would lend support to Healy's theory. The fact that gingivitis and periodontoclasia can be treated as local infectious conditions and almost invariably be cured as far as active manifestations are concerned, without consideration of possible allergens, seems to discredit the idea that these diseases are in any sense allergic manifestations. An allergic reaction does not need to be postulated to account for the irritating effects on the gingivae of putrefying globulin deposited from the saliva or of intestinal contents regurgitated and spread on the teeth.

The subject of food deficiencies offers a more fruitful field of study for possible dietary factors in periodontal disturbances. There are now known to be about forty substances which must be obtained from food in order that the human body may function properly. There are more than twenty amino acids, of which several can be synthesized in the human body. Choline and some unsaturated fatty acid are necessary, at least for some mammals. Some source of pyrrole may also be necessary. The carbohydrate glucose and fat can be synthesized in the body from amino acids, but there are advantages in having them in the food. Six necessary vitamins have been definitely identified as chemical entities, and there is reason to believe that there are others as yet not so identified. Besides water, there are eleven mineral elements essential for the construction of tissues or for regulating metabolism. These are calcium, phosphorus, iron, sodium, potassium, magnesium, copper, zinc, manganese, chlorine and iodine. Sulfur is essential, but only as it occurs in organic combination in several of the amino acids and vitamins. Of these necessary nutrients which must be obtained from food, only a few are of direct interest to the dentist because a deficiency may have effects on the teeth or their supporting structures. These are four of the six or more vitamins and the minerals calcium, phosphorus, iron and iodine. The possible effects of limitation of water intake on mouth health have already been mentioned. Deficiency in amino acids and the remaining minerals is so infrequent under modern conditions of living in America that it is not important to dentists.

THE VITAMINS

Vitamin A ($C_{20}H_{29}OH$) is a fat soluble colorless substance which is related to, and can be formed in the body from, four of the plant pigments of the carotene group. It cannot be formed from the common yellow plant pigment xanthophyl. It is found in greatest abundance in certain fish oils, especially halibut liver oil and cod liver oil. The vitamin or its carotene provitamins are found in cream, butter, cheese, egg yolk, liver, certain red and yellow vegetables and fruits and the leaves of green vegetables and, in much smaller quantities, in whole grain and beef fat. There is practically none in lard or commercial vegetable oils. It is stored in the body in considerable quantities. It is destroyed by oxidative processes, but not

by the heating of cookery. The most common effects of its deficiency are, in order of their appearance: night blindness, drying of the skin, reduced resistance to infection, keratinization of mucous membranes, stoppage of growth, interference with tooth formation, digestive disturbances, loss of weight and keratinization of the tear and salivary glands, with loss of secretion followed by ulcerations of the cornea. There are believed to be no dangers from excess consumption of the vitamin or its carotene provitamins. An excess above the usual storage ability of the body leads to a harmless yellow coloring of the body fat, which gives a yellow coloration to the skin.

As measured by tests of night blindness followed by vitamin A administration, deficiency is rather common. Jeans and Zentmire[8] state that they found relative night blindness to be extremely common among children entering the University Hospital in Iowa. Among 233 children, 21 per cent had a relatively poor adaptation which became normal on a satisfactory dietary with cod liver oil. Eddy and Dalldorf[9] state that a similar condition seems to exist in New York City among small numbers of persons whom they have tested. Evidently, deficiencies sufficient to have definite but delicate clinical signs are not so uncommon in America as might be assumed from the relative rarity of the recognized advanced forms of deficiency disease. In view of the findings of Sherman[10] that four times the minimal amount of the vitamin necessary for growth and reproduction is desirable for maximal health and longevity, it is probable that suboptimal intake and storage is relatively common. According to Mathews,[11] the optimal amount is from 3 to 5 mg. a day of vitamin A or carotene (5,000 or more international units). This amount is present in (1) one-third ounce of cod liver oil, (2) from 4 to 10 ounces of butter, (3) 2 ounces of spinach and (4) 6 eggs.

Deficiency in vitamin A is particularly important in relation to periodontal disease because one of its most important manifestations is reduced tissue resistance to bacterial invasion. It is extremely probable that a vitamin A deficiency too slight for ordinary medical recognition plays an important part in the rapid bacterial invasion and progressive breakdown of the periodontal tissues in many persons. No definite research on human beings to establish this point has been done, to my knowledge, but some animal experimentation is suggestive. Indications for it are seen in the work of Grieves[1] and of Marshall,[12] who obtained marked periodontoclasia in rats and dogs by feeding vitamin A deficient diets. It is interesting to note also that the veterinary officers in the zoo, by feeding vitamin concentrates, principally A, C and D, to giant apes, prevent periodontoclasia in these animals, which are greatly predisposed to this disease while in captivity.

While it is probable that a slight vitamin A deficiency contributes to gingival infection in many cases, it is a fact that dietary defects seldom go singly, and it is probable that, in most cases, the lack of resistance, when of nutritional origin, is due to a combination of defects. A diet sufficiently lacking in milk products, eggs, liver and leafy vegetables and fruits to be deficient in vitamin A would almost certainly be deficient in calcium and probably other vitamins as well.

Vitamin B_1 ($C_{12}H_{16}N_4OS$) is a water-soluble substance found most abundantly in yeast and in the embryo and coats of the seeds of plants, and in lesser degree in eggs, milk and the leaves of plants. It is easily destroyed by the action of alkalis and by autoclave heating, but not by ordinary cooking. It is not stored in appreciable quantities in the body. The deficiency of this vitamin causes changes in the alimentary tract leading to loss of appetite, poor digestion and absorption, constipation, decline in weight, loss of vigor, failure in growth, sterility, cardiac

weakness, edema of the ankles and finally nerve degeneration leading to paralysis. In its fully developed form as seen in the Orient, it is called beriberi. In mild deficiencies, it increases the tendency to allergic phenomena and reduces the resistance to infection. The vitamin is rapidly used up in infectious conditions and more is required in periods of infectious illness than under normal conditions. It is associated with carbohydrate metabolism and the data suggest that deficiency may be a cause of diabetes. A high carbohydrate diet requires for its metabolism an increased amount of vitamin B_1. The successful use by Gerstenberg[13] of this vitamin for the treatment of herpes labialis and herpetic stomatitis indicates that these lesions may be deficiency symptoms.

It is a fact that the addition of vitamin B_1 in the form of cereal embryo or yeast benefits many people. Summerfeldt, Dennet, Morgan, Eddy and Dalldorf[14] and others report increase in weight, appetite and growth, recovery from tuberculosis and resistance to infectious disease in children when vitamin B_1 has been added to a presumably good basal diet. The successful use of yeast and bran in curing many cases of constipation and intestinal indigestion is evidence that these products have value because of their vitamin B_1 as well as their roughage factors. McCarrison[15] has shown both by animal experimentation and by observations on human beings that vitamin B_1 is often below the optimum in many diets in Europe and America and that this leads to gastro-intestinal derangements, colitis, loss of appetite and loss of vigor. Nervous manifestations appear later. It is easy to use a diet that is deficient. Unless unrefined grain products are ample in the diet, it is almost sure to be deficient in vitamin B_1. Eddy and Dalldorf, in their book, give the requirements in terms of units together with the units found in ounce quantities of the common foods. There is no evidence of harmful effects from an excess of this vitamin in the diet.

There is, to my knowledge, no research that bears directly on vitamin B_1 deficiency as a cause of periodontal disturbance. No mention is made of destructive lesions of the periodontal tissues in reports of animal experiments on vitamin B_1 deficiency; nor are there any reports of improvement in these lesions in human beings from the administration of the vitamin. The best evidence that there is a relationship lies in the fact that periodontal disease is prevalent in regions where vitamin B_1 deficiency occurs and is practically absent in regions where the people live on unrefined cereals and other forms of unrefined foods. Since it has been proved that a deficiency of this vitamin decreases resistance to infection, it is probable that the deficiency contributes to periodontal infection. It is also probable that advanced periodontal disease helps to cause gastro-intestinal disturbance through the well-established fact that infection creates a greater demand for vitamin B_1 as well as for other factors than would otherwise exist.

Vitamin B_2, or G ($C_{17}H_{20}N_4O_6$), a water-soluble growth-promoting and pellagra-preventing factor, appears at present to be an acriflavine. There is some confusion as to whether this is a single factor or several closely related chemical factors having different nutritional properties. It occurs in quantity in yeast and is also found in milk, eggs and all green vegetables. It is chiefly of interest in dentistry, owing to the fact that lesions of the oral mucous membrane and tongue are among the first to develop in pellagra. Disease due to deficiency of this vitamin appears to occur only in persons who are on an extremely restricted diet. A mild deficiency of this vitamin alone is probably not a factor in gingivitis and periodontoclasia among the rank and file of Americans today. It is possible that such a deficiency may add to the bad effects of other deficiencies.

Vitamin C ($C_6H_8O_5$), cevitamic or ascorbic acid, is a water-soluble factor, the lack of which causes scurvy. It is found most abundantly in citrus fruits, tomatoes and green leafy vegetables. It is easily destroyed by heating in the presence of oxygen, but by special methods now known to the canning industry, it is well preserved in canned foods, especially tomatoes. The first effects of deficiency of this vitamin appear in the pulps of the teeth, after which the periodontal tissues are affected. To quote Eddy and Dalldorf[16]:

The gums become swollen and bleed easily and rarefaction of the bone causes the teeth to loosen and fall out. The characteristics of the gingival lesions are a rapidly developing hyperplasia of the papillae with a tendency to spontaneous and intractable hemorrhage, disintegration of the epithelium commencing on the papillae and followed by the development of granulation tissue and finally gangrene (Westin). Trauma obviously plays a large part in localizing these lesions since they do not occur at all unless teeth are present, and then at sites of greatest irritation and stress.

They say further[17]:

The association of the gingivitis and scurvy is fundamental. There are no criteria for identifying scorbutic gingivitis unless perhaps when fully recovered. Hanke, after feeding large doses of orange juice to children, observed that they were remarkably free of gingivitis and any tendency to bleed from their gums. The supposition that sub-clinical scurvy may be responsible for many cases of soggy, bleeding gums seems to be supported by the experience of a number of physicians. Nordenmark found that two-thirds of his cases of gingivitis in children were associated with abnormally low capillary resistances. Vitamin C produced improvement in the gingivitis and raised the capillary resistance in eight of nine cases.

There are several tests for vitamin C deficiency, none of which is altogether satisfactory. One of these is a test for capillary fragility. Mild suction applied to the skin causes petechial hemorrhages to appear. The greater the capillary fragility, the less the suction required to cause the hemorrhages. Unfortunately, the thickness of the skin and other unknown factors create differences among individuals which decrease the quantitative value of the test; but it is most useful in watching the progress of the individual who is under treatment in which large doses of vitamin C are used.

The vitamin, in large doses, seems to have a specific effect of increasing capillary resistance even when capillary fragility is due to other conditions than deficiency in the vitamin. While 7.5 mg. of vitamin C daily will protect the adult from scurvy and 20 mg. is the accepted optimum in the diet, 200 mg. daily over a period of weeks appears to be beneficial in conditions in which capillary fragility plays a part, such as gingivitis. There is no known danger in excessive dosages of the vitamin. The excess is simply excreted in the urine. To get an idea of the amount of common foods necessary to obtain the accepted optimum of 20 mg. of cevitamic acid daily, it may be stated that such an amount is contained in (1) 2 ounces of fresh orange juice, (2) 4 ounces of fresh tomatoes and (3) 11 ounces of cooked fresh spinach.

Another test is a quantitative determination of the reducing substances in a twenty-four hour specimen of the urine. Twenty milligrams of reducing substance should be present to indicate optimal ingestion and absorption of the vitamin.

Wolbach and Howe[18] have shown that the chief effect of vitamin C lack in the periodontal tissues is the change that occurs in interstitial material. The normal periodontal tissue is replaced with a soft non-fibrous hemorrhagic tissue which no longer suspends the tooth in its socket, but allows it to bump back and forth, to the injury of the surrounding bone. In addition, the bone itself, being interstitial tissue, is rarefied and no longer offers a strong support. Bacterial invasion in human beings leading to deep periclasial pockets of course follows where such degeneration changes have occurred

in the periodontal structures. Howe[19] shows that any of the types of gingivitis, alveolar atrophy and periodontoclasia may occur from deficiency of vitamin C. This work is further substantiated by Boyle,[20] working with Howe, who shows that a large proportion of the periodontia patients coming to the Harvard Dental School clinic have gingivitis and periodontoclasia, which is largely due to lack of vitamin C, as disclosed by urine tests and by increase in cevitamic acid intake.

Vitamin D ($C_{27}H_{41}OH$) (calciferol) is a fat-soluble factor which is concerned in regulating the absorption, retention and metabolism of calcium and phosphate in the body. It is found in greatest abundance in cod liver and some other fish oils and in lesser amounts in summer butter and in liver and other animal organs. Its provitamin ergosterol is activated by the action of ultraviolet light to form the vitamin. Since ergosterol is present in nearly all animal and plant tissues, it is possible by irradiation to produce the vitamin artificially in many foods. Ergosterol in the skin is thus activated and the action of sunlight or other sources of ultraviolet light on the skin may take the place of the vitamin in the food.

A deficiency of this vitamin with calcium phosphate imbalance in young children causes rickets and in adults a rarefying bone disease called osteomalacia. It is particularly necessary that this vitamin be present in abundance if there is a faulty proportion in the intake of calcium and phosphate in the food. A high calcium and low phosphorus or a low calcium will invariably lead to bone disturbance unless the vitamin is present in optimal amount. If the calcium and phosphate are properly balanced in the diet, a deficiency of the vitamin does not have so severe an effect. It is possible to get an excess of vitamin D. Experiments with rats on excessive intake indicate that cartilage becomes calcified, spongy bone becomes compact and areas of calcification occur in many organs. However, since the dosage, to become toxic, must be a hundred or more times the therapeutic dose, the danger of hypervitaminosis in human beings is relatively remote.

This vitamin is of particular interest in dentistry because the two most common dental diseases, dental caries and periodontoclasia, are both associated with calcium-phosphate metabolism and both appear to be caused by deficiency of the vitamin. The evidence is at present very confusing, and the exact mechanism by which vitamin D deficiency combined with calcium phosphate imbalance causes dental caries susceptibility or susceptibility to periodontal tissue invasion is by no means clear. The work of Mellanby[21] and Grieves[1] seems to indicate that periodontoclasia can be quite commonly produced in the rat or dog by calcium phosphate imbalance plus a deficiency in vitamins A and D. Since it is D vitamin that regulates the calcium and phosphate balance, it is probable that deficiency of vitamin D is of more importance than that of itamin A in those disturbances in which bone destruction is extensive.

Vitamin D is very commonly deficient in the human being. The prevalence of rickets until pediatricians came to insist on the use of cod liver oil or viosterol for all young children indicates the difficulty of obtaining it in optimal amounts. It is not present in large enough quantities in ordinary foods to be optimal unless the person is exposed to sunlight more than most persons are during the winter months. It is probable that the failure may soon be made good by means of irradiating milk or putting viosterol in bread, or by other artificial methods increasing the content in common foods.

Vitamin E ($C_{29}H_{50}O_2$) is a fat soluble factor found in wheat germ which is necessary in certain mammals to prevent death and absorption of the embryo after fertilization. So far as known, it has no function in any way related to periodontal

disease; hence, no further mention will be made of it.

THE MINERALS

Of the minerals which may be deficient in the diet, calcium and phosphorus seem by far the most important in connection with dental disease. As was indicated above, the mechanism by which the ill-effects on the teeth and supporting structures are brought about by a poorly balanced calcium and phosphate content is not fully understood, but recent researches are making the subject more intelligible.

Calcium is found in abundance in milk and cheese and in small amounts in leafy vegetables. Sherman[22] has calculated that the child or nursing mother needs at least 1.6 gm. of calcium a day and an ordinary adult perhaps half of that amount. A quart of milk contains 1.2 gm. of calcium. It also contains 0.9 gm. of phosphorus, another element likely to be deficient unless milk or milk products, meat and eggs form an important part of the diet.

An insufficiency of calcium or phosphate or vitamin D leads to faulty bone formation including the arrested development so commonly seen in orthodontic practice and which leads to periodontal weakness. Imbalances in animals and probably in man lead to increased susceptibility to dental caries and to periodontoclasia.

The type of dietary, i.e., whether alkaline or acid ash, possibly determines whether the effect is caries or periodontoclasia. An alkaline ash type of diet seems to tend toward sordes and calculus formation in the mouth according to Jones.[23] If carried far, as by the administration of sodium carbonate, it causes bony decalcification, according to Jones and Simonton,[24] probably from loss of phosphate in the urine, leaving the calcium high in amount in relation to the phosphate. The acid ash type of diet, on the other hand, tends to the elimination of both blood calcium and phosphate in the urine, thus reducing both to below optimal body requirements and tending to make the saliva less protective against dental caries. The subject of acid-base balance of foods in relation to acid-base balance of the body is still in a highly controversial state, and too much dependence should not be placed at this time on glib hypotheses which explain dental caries and periodontoclasia in these terms.

Iron and iodine are two other minerals sometimes deficient in the diet. Insufficient iron or loss of iron leads to anemia, which causes lowered resistance and hence tends to aggravate any tendency to gingival infection. A sufficiency of eggs, meat and leafy vegetables excludes the probability of deficiency of this factor. Lack of iodine leads to simple goiter. Iodine is another factor that is demanded in increased amounts in infection, according to McCarrison.[15] As deficiency is not known to cause periodontal disturbance, it may be passed by in this discussion.

SUMMARY

In recapitulation, it may be said that dietary factors may cause periodontal disturbances in several ways.

1. A dietary of easily masticated food leads to hurried eating, resulting in underdevelopment and insufficient functioning of the periodontal tissues, which are easy prey to bacterial invasion. It also leads to uncleanness of the teeth through deficient detergent action and insufficient salivary stimulation.

2. A tendency to caries about the teeth, due to carbohydrate food residues, accentuated by insufficiency of calcium and phosphate and vitamin D, combined possibly with an acid ash type of diet, causes a marginal gingivitis, but seldom a deeper periodontoclasia.

3. Heavy deposits of soft débris from the saliva follow overeating in many persons. This often leads to salivary calculus formation. Calculus seems to occur

in those on an alkaline ash type of diet and is perhaps due to loss of phosphate, leaving a relative excess of calcium. These deposits lead to heavy bacterial growth on the teeth and tend to deep periodontal invasion and pocket formation.

4. Irritating soft deposits occur in certain neurotic persons from reverse peristalsis and lead to a particularly severe inflammatory and destructive gingivitis.

5. Food poisoning and allergy do not appear to be common causes of periodontal disturbances.

6. Vitamins A, B, C and D are very often deficient in the diet. Deficiency of one or more of A, B and C leads to lowered resistance to infection and opens the way for invasion by ever-present mouth organisms. Deficiency of vitamin C and perhaps less of vitamin A seems to be a frequent cause of generalized gingivitis in childhood. Deficiency in vitamin D leads to failure to balance calcium and phosphate in the body.

At the present writing, dietetic control in periodontal disturbances seems to lie in teaching people to eat moderately of food which requires vigorous mastication and to cultivate the habit of vigorous, slow, efficient mastication. Starchy and sweet foods of a consistency likely to leave a residue on the teeth should not be eaten at the end of the meal or between meals. The diet should be amply fortified with vitamins A, B, C and D, either in the form of foods rich in these factors or, if this is impractical, by means of vitamin concentrates. Calcium and phosphate must be present in optimal amounts, and if these cannot be obtained by the use of milk, cheese, eggs and meat, they may be had in the form of calcium phosphate preparations.

The evidence indicates that dietary factors cause periodontal disturbances for the most part by increasing bacterial growth on the teeth and lowering resistance to bacterial invasion of the body tissues, including those of the periodontium. There is apparently no one dietary factor which is alone responsible. Dietary deficiency in vitamins and minerals react to each other in such a way that similar results may occur from several types of deficiency. Nina Simmonds states that in a study of more than 500 patients at the University of California Dental College, the vast majority were found to be suffering from the effects of ill-balanced diets, deficient in one or more of the factors here discussed. Her findings, if they are applicable to the general population, account for the 98 per cent of dental caries and the wide prevalence of gingivitis and periodontoclasia, from which wild animals and primitive man in their native habitats are practically free.

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630 West One Hundred and Sixty-Eighth Street.

GENESIS OF THE PERIODONTIUM*

By Theodore B. Beust,† D.D.S., Louisville, Ky.

THE periodontium, whenever present, whether in mammal or in lower vertebrate, is obviously a product of metamorphosis of the tooth sac. As this view seems to be generally accepted, a discussion of the phylogenetic development of the periodontium of mammals seems to be indicated.

Of all animals known to possess a periodontium, the lowest in the vertebrate scale is the alligator. (Fig. 1.) There can be no doubt of the identity of the membrane attaching the teeth of this animal to their sockets. Looking lower in the line of ascent, to the teeth of fishes, we find, according to Tomes' anatomy,[1] the comments of Malassez, who compares the periodontium with the fibrous bands which in some fishes serve to tie the tooth down to the bone where no tooth socket

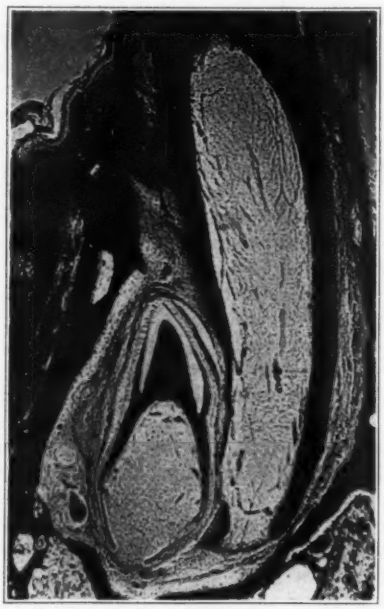

Fig. 1.—Tooth of alligator with periodontal attachment.

(Read before the Section on Histology, Physiology, Pathology, Bacteriology and Chemistry [Research] at the Seventy-Ninth Annual Session of the American Dental Association, Atlantic City, N. J., July 15, 1937.)

*From the Biologic Research Laboratory, School of Dentistry, University of Louisville.

*Work supported in part by a grant from the Research Commission of the American Dental Association.

†Deceased.

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exists and holds that it is strictly homologous with these. While this concept may be sound, it appears that the earliest logical time to undertake studies of relationships with reasonable anticipation of

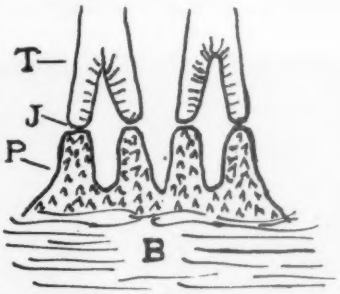

Fig. 2.—Diagram of pedestal: T, tooth. J, joint. P, pedestal. B, bone of jaw.

Fig. 3.—Ground section of tooth of *Sargus*. J, joint. P, pedestal or root.

tangible results would be coincident with the earliest attempts by Nature to form the primitive tooth root because rooted teeth in fishes, whether attached by fibers or ankylosis, must of necessity exhibit a membranous attachment derived from the tooth sac for at least the period between eruption and definite alinement in the occlusal plane. This statement will be illustrated in the following discussion.

Possibly the most primitive structure leading to root formation is a type of pedestal, formed of the so-called bone of attachment, by which the teeth of some fishes, such as the eel and haddock, are secured to the bone. (Fig. 2.)

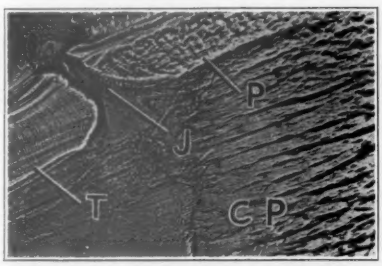

Fig. 4.—Ground section of tooth of *Sargus*. J, joint. P, pedestal. CP, calcified pulp. T, tooth crown.

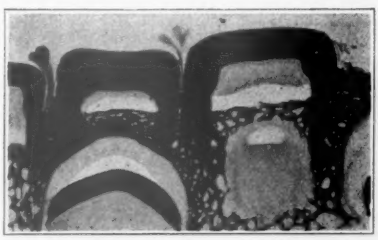

Fig. 5.—Ankylosis in *Sargus*.

In a preliminary announcement made at the Twenty-Fourth Meeting of the Kentucky Academy of Science in May 1937, the so-called tooth root of *Sargis ovis* was given consideration. (Fig. 3.) In the teeth of this fish, a joint is conspicuous at the point where the crown joins the embedded part. (Fig. 4.) The embedded portion is firmly knit to the jaws by ankylosis. (Fig. 5.)

We find significant statements in Tomes' Anatomy,[1] page 240, concerning that part which corresponds to a root:

Another instance of the formation of a kind of pedestal which in this instance is sunk within the substance of the surrounding bone

Fig. 6.—Section of premaxilla of *Sargus* showing joints and follicles.

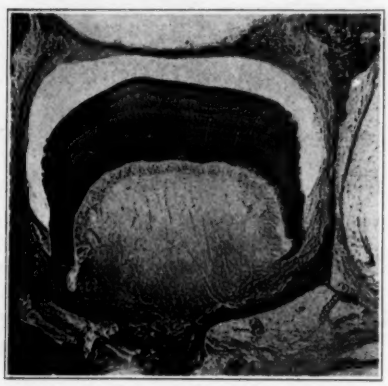

Fig. 7.—Palatine tooth of *Sargus* about to erupt; showing joints enclosed within follicle.

is found in *Sargus*. Here the attachment of the working tooth to the subjacent portion is by means of fibrous tissue, though the submerged part appears in this case to be made by the pulp itself.

Tomes' statement leaves us in doubt as to whether we are here dealing with a pedestal or with a true tooth root. By "pedestal," a bone of attachment which

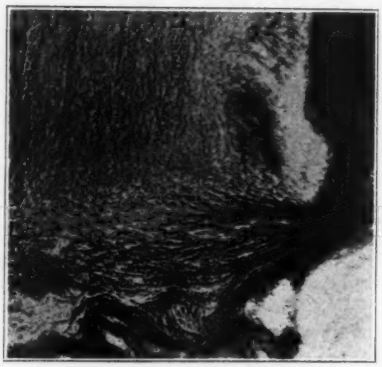

Fig. 8.—One side of tooth shown in Figure 7 presenting fibers of tooth sac. (16 mm.)

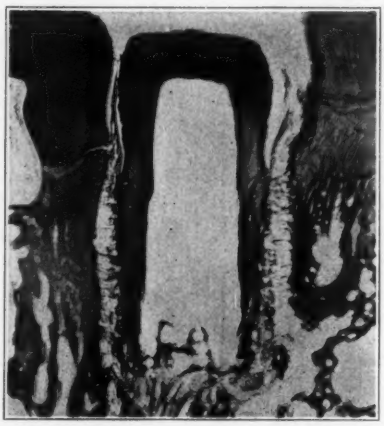

Fig. 9.—*Sargus;* newly erupted tooth with periodontium, before ankylosis.

is laid down for the attachment and support of rootless teeth is commonly understood. (Fig. 2.) By "tooth root," we understand additions to the basal part of

the crown formed within the follicle that are destined to hold the tooth in its socket.

Slides made from the jaws of *Sargus* display numbers of teeth with their embedded successors lying in crypts. (Fig. 6.) Careful study of large numbers of sections discloses that in *Sargus*, we are

Fig. 10.—Second specimen, showing periodontium.

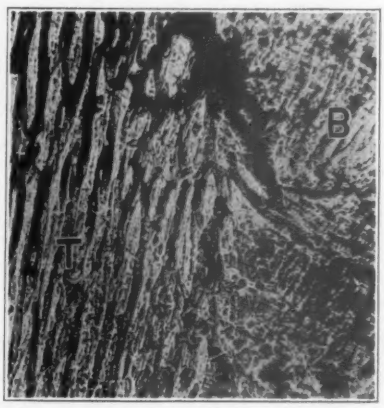

Fig. 11.—Barracuda; ankylosis. T, tooth. B, bone.

dealing with true tooth roots, not with pedestals. The so-called pedestal is here shown to be formed within the root sac. (Fig. 7.) A closer view of one side of the specimen is seen in Figure 8. My contention that all erupting rooted teeth, even if later to become ankylosed, are held in place for a variable time by a fibrous

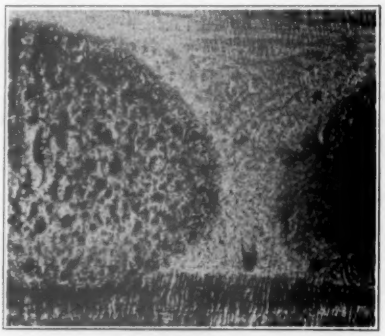

Fig. 12.—Barracuda; ankylosis; showing roots in cross section.

Fig. 13.—Barracuda; young tooth germ with tooth sac.

union homologous with the periodontium of mammals may now be demonstrated.

Between eruption and full alinement, a fibrous union derived from the root sac is present. (Figs. 9 and 10.)

Another example illustrating the occurrence of a transitional fibrous attachment derived from the tooth sac is found in *Sphyraena barracuda,* commonly known as the barracuda pike. A preliminary study of this dentition was presented at the twenty-third annual meeting of the Kentucky Academy of Science in May 1936. It was at that time shown that the mature teeth of the barracuda were inseparably ankylosed to the jaws. Sections of the different categories of teeth, cut at different levels, leave no doubt as to this condition. (Figs. 11 and 12.)

Fig. 14.—Barracuda; young tooth about to erupt.

The teeth of this fish are admirably adapted for study of the transition of the tooth sac into periodontium. In Figure 13 is seen a socket completely filled with a germ and its enveloping sac. Figure 14 shows a later stage with enlarging tooth and disappearing sac. Further development culminates in the stage wherein the erupted tooth supported by fibrous tissue derived from the tooth sac elongates in the direction toward the occlusal plane; whereupon the membranous attachment will be superseded by one of ankylosis. (Fig. 15.) In the barracuda, the fibrous attachment, owing to the great depth of the socket, probably persists for a long time, the necessity for immediate ankylosis not being obvious.

The two examples herein described illustrate that structures both functionally identical and homologous with the periodontium of mammals are present during tooth development in animals belonging to a zoologic class below that of the crocodile.

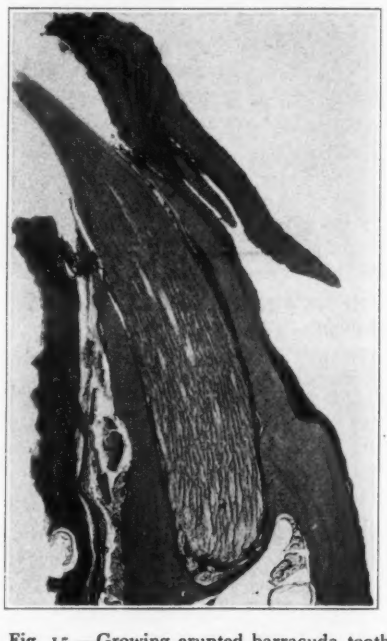

Fig. 15.—Growing erupted barracuda tooth with periodontium, prior to ankylosis.

This evidence serves to further shorten the gap between fish and mammal.

CHEMICAL DETERMINATION OF VITAMIN C DEFICIENCY AS RELATED TO GINGIVAL DISEASE

By Don C. Lyons, D.D.S., M.S., Ph.D., Jackson, Mich.

MANY references in dental and other scientific literature definitely establish a relationship between vitamin C deficiencies and gingival disease or abnormalities. Owing to general improvement in dietary knowledge and in diets, cases of typical acute scurvy are very rare in this country. However, many cases of mild subacute or chronic C avitaminosis are found, and these have been previously described by others. This condition may be described as a gingivitis of some months' standing with the gums puffy to the point of losing their stippling, slightly glazed or dry and rolled in the interproximal spaces and along the gum margin, with a color change to a deep red. A very noticeable diagnostic feature is the fact that there is only a slight amount of tartar formation; or there may be none at all, indicating that local irritation is not a factor in the gingivitis.

This type of gingivitis has been recognized as being caused by some systemic condition. When vitamin C deficiency is the causative factor, this particular oral condition has heretofore been treated empirically because of lack of an exact method of determining the degree or quantity of the deficiency.

We cannot assume that if one eats indefinite but large quantities of food known to contain amounts of vitamin C, he is actually assimilating the amount of vitamin sufficient for his needs. Such an assumption is subject to too many probable errors; for we do not always know how many milligrams of vitamin C there are in the particular portion or portions of food eaten. On the other hand, we do know that vitamin C is easily destroyed by oxidation; that our present methods of cooking are highly destructive to this vitamin, and also that there is considerable seasonal variation, storage loss and other opportunities for diminution or change in the assumed vitamin C content of any diet.

(Read before the Section on Histology, Physiology, Pathology, Bacteriology and Chemistry [Research] at the Seventy-Ninth Annual Session of the American Dental Association, Atlantic City, N. J., July 14, 1937.)

DETERMINATION OF VITAMIN DEFICIENCY

When the chemical nature of vitamin C was determined as a hexuronic, or ascorbic, acid, a number of tests were devised to determine the presence of this acid quantitatively in foods, plants, tissues and fluids. We are indebted to the work of Svirbely and Szent-Gyorgyi, von Erler and Kussman, Harris, Ray, Birch and others for these tests. One important discovery has been a urinary test which gives an accurate chemical determination of the degree or amount of vitamin C intake and so makes it possible to determine whether oral conditions are due to vitamin C deficiency and, if so, the amount of deficiency present.

PROCEDURE

This test is based upon the excretion of a residual amount of vitamin C in the urine. It has been shown that the average adult needs daily from 120 to 150 mg. of vitamin C and should excrete not less than a minimum of 20 mg., with 30 mg. a normal average.

A composite fresh twenty-four-hour sample of the urine to be tested is obtained. A small amount of acid, trichloracetic or glacial acetic, is placed in the collecting bottle to keep the specimen acid. This is necessary because if the specimen remains neutral or becomes alkaline, the glutathione in the urine will react with the indicator, and the results of the test be unreliable. This compound, which is the tripeptid of glutanic acid, cysteine and glycene, is a very active oxidation-reduction catalyst and so must be removed to prevent possible errors in the calculated results. As cysteine and various phenolic compounds also found in the urine will reduce the indicator in acid solution, these also must be removed. This separation is accomplished by the method of Emmerie, as follows:

A 20 per cent solution of mercuric acetate is prepared with distilled water. This is permitted to stand twenty-four hours and then filtered, as some hydrolysis takes place. A fresh solution should be prepared at frequent intervals because of the relative instability of the solution.

A comparative amount of the urine specimen is then measured out. Usually, a 100 milliliter sample is sufficient. The excess acid in the sample is neutralized with calcium carbonate. Then the 20 per cent mercuric acetate solution is added slowly, drop by drop, to the specimen, until the creamy white precipitate which develops is complete. Care must be taken not to use an excess of mercuric acetate, since, in such a case, the precipitate will redissolve.

If there is any question whether the glutathione has been completely removed, the sample may be tested by treating an aliquot with potassium nitroprusside in the presence of ammonia. If glutathione is present, a purplish red coloration will develop in the solution.

The precipitate is allowed to settle and the top fluid decanted off and filtered. This is quite necessary because the thick flocculent precipitate makes filtration difficult if there is a large amount in the sample.

With the completion of this step, a 20 milliliter portion is measured into a beaker and acidified with 2 milliliters of acid. One may use either trichloracetic or glacial acetic acid as the acidifier, there being apparently no difference in the end result. The acidified sample is then titrated with a standardized solution of dichlorphenol-indophenol. This blue dye can be obtained, if desired, in a convenient tablet form containing a measured amount. One tablet when diluted with 50 milliliters of water is sufficient to titrate one mg. of ascorbic acid. The indicator dye is placed in a buret and slowly added to the test solution, until a pink coloration develops, which persists for at least thirty seconds.

The results are then calculated as follows: If 50 milliliters of indicator will titrate 1 mg. of ascorbic acid, 1 milliliter is equivalent to 0.02 mg. Therefore, if, for example, it takes 20 milliliters of the indicator to titrate the 20 milliliter specimen, there is twenty times 0.02, or 0.4 mg., of ascorbic acid in the specimen. Knowing this, one then calculates the daily excretion of vitamin C from the total twenty-four-hours' output of urine. For example, a 2-liter output in the foregoing case would mean a daily excretion of 40 mg. of vitamin C. This test is accurate even in minute amounts, as has been proved by spectrographic analysis.

It is necessary to use a composite twenty-four-hour sample because the vitamin C excretion rises rapidly after a meal, showing up first within one hour and reaching a maximum within three hours and returning to the original level within fifty hours. Therefore, it is advisable to make a series of tests and use an average of the series for the diagnostic basis. It has been shown that a definite relation exists between intake and excretion, although individual variation has made it impossible so far to determine the upper limits. Apparently, the adult

human being should have a diet containing at least 120 mg. of vitamin C per day, and the minimum excretion should be not less than 20 mg. When the amount of the deficiency is known, it is possible to correct the intake to the point where normal levels will be obtained.

The following typical case history illustrates the practical value of this test.

REPORT OF A CASE

A woman, aged twenty-four, apparently in average health, complained of bleeding gums which were sufficiently painful to cause her to become alarmed and seek treatment. Examination showed that the mouth was clean, and it presented evidence of good dental care. There were no cavities in the teeth nor any incomplete dental restorations. The gums were swollen at the gum margins and bled easily on slight pressure. There was no tartar accumulation and the patient stated that she had had her teeth cleaned by the family dentist regularly once every three months. However, the regular routine of prophylaxis had made no change in the gum conditions. Examination of a composite urine specimen showed that the daily vitamin excretion during the first eight days of the tests was as follows:

2,100 milliliter output 3.60 milliliters vitamin C.

2,350 milliliter output 3.29 milliliters vitamin C.

2,375 milliliter output 3.77 milliliters vitamin C.

2,310 milliliter output 3.61 milliliters vitamin C.

Average 3.56 milliliters vitamin C.

Such a vitamin C excretion is abnormally low and warrants extensive treatment. The diet was then changed by adding 3 ounces of tomato juice and 8 ounces of mixed orange and lemon juice to the diet each day, or the estimated equivalent of 200 mg. of vitamin C.

The tests were then repeated and, during the first two weeks, the daily vitamin C excretion was brought up to 18.4 mg. An additional change was then made in the diet, bringing the daily intake of vitamin C up to 250 mg. By the end of the fifth week, the daily excretion averaged 29.4 mg.

By the end of the test period of increased vitamin C intake, the gums had become firm and pink and no longer bled on brushing. All pain had disappeared.

While this case illustrates treatment with natural vitamin C containing foods, similar results and more predictable ones can be obtained by using the synthetic or concentrated natural vitamin C in known doses or units.

CONCLUSIONS

This test should become a valuable adjunct in the treatment of gingival diseases as it solves the diagnostic problem of whether there is a vitamin C deficiency associated with the gingival condition under treatment. One must, however, continue to study the case to the fullest extent in order to rule out all possible complications or other associated conditions. If the dietary relationship has been definitely established, this test permits treatment on a rational basis without empiric guesswork. It simplifies treatment of the diagnosed cases because the amount of vitamin deficiency can be accurately determined and normal levels reestablished in a shorter period of time.

From a laboratory standpoint, it may be used as a measuring unit by which extensive research can be done on dental dietary problems without the equipment necessary to animal experimentation.

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National Bank of Jackson Building.

DIET DURING CHILDHOOD

By Dorothea F. Radusch, D.D.S., B.A., Minneapolis, Minn.

DIET during childhood is an important consideration of the parent, physician and dentist. Yet, because health or disease of the body is dependent on a multiplicity of factors, some general, some local and some environmental, no specific diet can be expected to cure or to prevent all dental caries. All nutritional information suggests that diet is one of the controlling factors, beginning in the prenatal period, carrying on through the tooth-developmental period and possibly influencing the environmental, through the salivary composition, during the entire lifetime.

Nutritionists believe that diets are seldom as adequate as they may seem. The mother's estimate of what the child eats, especially when there are several children in the family, is frequently not substantiated when records of foods eaten are kept. Individual preferences may result in very adequate or very inadequate food consumption from the same table.

No country has yet attained the standard which secures to children the essential basis of sound nurture. Surveys made by various groups, including the League of Nations Committee on "The Problem of Nutrition," report that in the countries of Europe and those of western civilization "deficiencies in important nutrients are a common feature of modern diets, and that these deficiencies usually occur in the protective foods (foods rich in minerals and vitamins) rather than in the energy giving foods (protein, fats, and carbohydrates)." In the United States, the standard of living has been considered high, especially as to recent improvements in consumption of milk and other protective foodstuffs, yet inquiries by scientific workers have shown that a large number of people are improperly fed. Even in 1928-1929, a period of great prosperity in the United States, most families were living on inadequate diets.

That latent states of malnutrition are prevalent throughout the civilized world is evidenced by poor musculature, teeth of poor structure, anemia, chronic fatigue and a poor condition of the skin. Many investigators are of the opinion that dental conditions are the most delicate indicators of the nutritive state. These indications of disease are not generally, however, from the present medical point of view, regarded as evidence of malnutrition. Yet height and weight within accepted normal limits are not reliable evidence of good nutrition. Such averages of growth are made up of data on children who have received good, poor and indifferent care; whereas the accumulation of records shows that children from higher socio-economic groups and those receiving good care average consistently above these tables. In using

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height-weight scales, children of small stature are included in the undernourished groups, when actually they may be well-nourished, with well-developed muscles, good subcutaneous tissue and good posture. On the other hand, children up to weight or overweight, but with flabby tissue, are included in the good nutrition group. The combination of overweight and malnutrition was common among the children of Europe during and after the World War, when deficiency diseases and edema were prevalent.

Present reports on the effects of the depression on children indicate no regular decrease in height and weight of those in this group. In many cases, even an increase is found, being due, no doubt, to the high carbohydrate feeding in low-income groups. But other signs are suggestive of malnutrition. Physicians and health workers need to have a more comprehensive standard for judging good health and good nutrition. The League of Nations committee report states: "Nothing is more important than that a new attitude should be adopted towards this problem, for whereas such results of improper feeding as subnormal growth and weight and undefined general ill-health can usually be rapidly improved by better feeding conditions, the more chronic conditions due to earlier defective dieting cannot be so easily remedied, but continue to act as a handicap throughout life." Gross dietary deficiencies are not common in civilized countries, and many have yet to realize the importance of seemingly slight dietary changes and faults.

Dental disease and the possible rôle of diet therein is a subject of particular interest to dentists. Many workers have become discouraged because there has been developed no set of rules which will insure complete prevention and correction. "They forget that the pattern which results from similar causes cannot be the same unless every conditioning circumstance is the same and every force which is operating is of the same quality and intensity and acts upon material equally susceptible to it. Such coincidence probably never occurs." (Perkins.) Causes of disease often operate long before the disease can be recognized in the subject, and may not act directly.

One reason for varying results in children supposedly fed and subjected to the same environment after birth may be found in the fact that all children are not in the same nutritive condition when born. A review by Coons *et al.* (1935) of all published data on fetal analyses since 1858 emphasizes the conclusion that the fetus may arrive at term endowed with different reserves of minerals or with varying degrees of development attained during prenatal life. They state that doubtless such deficiencies explain the greater susceptibility of some infants to rickets, anemia and other manifestations of abnormal metabolism during the first year of postnatal life.

Coons and Blunt (1930) also found from roentgenographic examination of bones of normal infants from well-fed mothers that calcification was best when retention of calcium and phosphorus was best during pregnancy. Toverud, as reported in Garry and Stiven's Review (1936), made a study of two hundred skulls at birth and found that the mothers of "soft-skulled" infants had had a diet grossly lacking in calcium and phosphorus or were subject to pernicious vomiting; whereas the diets of the mothers of "hard-skulled" infants were completely adequate. Calcification of the metacarpal bones paralleled that of the skulls. Maxwell and Miles (1925) state that where extreme calcium-deficiency is known, as in China, infants born after the second pregnancy of the mother are osteoporotic and develop rickets. True fetal rickets accompanied by gross hypoplasia of the enamel of the teeth is also known there. Toverud (1932) reported congenital osteoporosis in puppies when the mother dog was kept on a diet deficient only in

mineral, yet with supplementary cod-liver oil throughout gestation and lactation. He states: "We have noticed as a common occurrence in our experimental work that the jaws among the different bones of the organism contain the broadest osteoid zones during an osteopathic process." When there are calcium and phosphorus deficiencies during fetal life, the offspring are born with general congenital osteoporosis, which probably is aggravated during lactation by a low calcium and phosphorus content of breast milk. Such reports give emphasis also to the fact that vitamin D cannot be expected to substitute for an adequate supply of minerals.

Booher and Hansman (1931) could find no relation between the calcification of the tibia and the milk intake of the mother and so concluded that, with respect to the deposition of the inorganic constituents of its bones, the normal human fetus may be regarded as entirely parasitic on the maternal organism. The bulk of other evidence from fetal analysis and animal experimentation contradicts this prevalent opinion that the fetus is completely parasitic and will therefore take everything it needs for development from its host. Many reports indicate that a number of exogenous factors, mainly dietetic, but also the socio-economic level, the type of work or activity preceding parturition, the season and the age of the mother have an influence on the nutritional development of the fetus. Children born of mothers in the higher socio-economic groups tend to be in better nutritional condition. It is interesting, when one considers the period of deciduous tooth development, that Cohen (1936) in his survey of the incidence of caries in school children noted that children from the higher classes socially have better deciduous teeth. The accumulating evidence is such that it can no longer be taken for granted that prenatal care is important only as a safeguard for the mother.

Extremely suggestive too are the reports of Schmitz in 1923 on twenty fetuses which, as his work was done in Europe soon after the World War, included chiefly the offspring of a generation of undernourished mothers, and the reports of Givens and Macy of twenty-five fetuses in 1923 and of Iob and Swanson of seventeen fetuses in 1934 in this country. All reported lower figures for calcium as compared to reports of around 1900, a period which represented an era of more liberal diets. Also, mineral balance studies on mothers of more recent years in contrast to early reports have shown a tendency to lower balances.

The Coons (1935) report of balance studies on pregnant women in Oklahoma indicates greater average retentions of mineral. This is interpreted by these authors to be due mainly to the greater amount of sunshine available than in Chicago, where their previous work had been done.

Bone and tooth development we know to be rapid during infancy and early childhood. According to Kronfeld (1935), deciduous crowns begin calcifying the fifth to sixth month *in utero,* and permanent teeth begin at intervals after birth, so that by the age of three years, calcification has begun in all teeth except the third molars. Permanent tooth crowns, with the exception of the third molars, are practically competely formed by the seventh year. Whether one believes in the primary importance of tooth calcification in caries prevention, it is only common sense that good sound structure is important to the long life of any object. Therefore, the period from birth to seven years has a special significance to dentists.

The common practice of bottle feeding with high carbohydrate additions gives flattering weight and growth rates, so that these children are generally well above established scales of measurement. But, unfortunately, even superior height, weight and growth rates are no positive indication of food nutrition. The Tech-

nical Commission of the Health Committee of the League of Nations states that the practice of giving cereal foods before the age of six months is not advised. After this age, the use of potatoes, suitably prepared, is advocated as a partial or complete substitute for cereals. The present gradual introduction of augmented cereals, such as the one devised by Tisdall *et al.* (1930), or other whole grain cereals, particularly in infant feeding, is to be commended. Such foods, as well as egg yolk, meat, fruits and vegetables, add to the rapidly depleting store of iron in the infant and supply vitamin B. This vitamin plays a substantial rôle in prevention of hyperirritability and anorexia in the child, thereby indirectly influencing the general condition of the teeth.

Full-term infants at birth have a store of iron which will help them over the initial milk-feeding period. The hemoglobin is reduced from approximately 100 per cent at birth, to about 70 per cent at three months. The administration of iron will raise the hemoglobin level, but inclusion of high iron foods from at least six months, and preferably earlier, is advisable. It has been shown that infants with low hemoglobin have a much higher sickness rate due to infections than those receiving iron. As all infections interfere with nutrition, and indirectly with body and tooth development, any factors lessening such likelihood of infection should be observed.

Vitamin D supplements in the child's diet to protect him from rickets have been quite generally accepted. Such therapy is complicated because the criteria for the diagnosis of rickets are not the same even among those conceded to be expert in the field (Jeans, 1936). At the present time, then, only when moderate or severe rickets is present can it be positively identified. Symptoms of mild rickets are not yet fully established; a situation which is paralleled in almost all cases of mild nutritional deficiency diseases.

The trend is to consider the minimum amount of vitamin D which will prevent rickets as adequate, but this concept may be as incorrect as the one that prevention of xerophthalmia is evidence of adequate intake of vitamin A. The range of variation of retention of calcium and phosphorus is narrowed when effective amounts of vitamin D are given, and a wide range is characteristic of small or negligible amounts of vitamin D. Also, if a relationship exists between the rate of growth and vitamin D as indicated by work of Stearns and Jeans (1936) and Daniels *et al.* (1929), rickets prevention cannot be the accepted criterion of an adequate vitamin-D intake.

Further evidence that such a criterion is not sufficiently comprehensive can be found in Mellanby's work on the types of tooth calcification as directly related to the amount of vitamin D provided during the formative period. As with rickets prevention, minerals as well as vitamins were essential to the formation of caries-resistant teeth, and results were observed which indicated that cereals, particularly oatmeal, possess anticalcifying properties which are more potent when vitamin D is low in the diet.

Mellanby's theories seem to be substantiated by researches of Eliot *et al.* (1934) and Anderson *et al.* (1934); whereas Hess *et al.* (1934), though deciding that caries of permanent teeth is not due to rickets, but to a nutritional disturbance occurring in childhood and early adult life, still advised the inclusion in the diet of a calcifying agent throughout these periods. Shelling and Anderson (1936) found no relationship between rickets and caries, but unfortunately their control and experimental groups were not comparable in age or race, and if, as various reports have suggested, Negro children are less susceptible to caries, the authors' conclusions are automatically annulled.

Thus, seeming variance in results of investigators may be explained by the fact that the different groups are not

comparable, some being composed of children having had institutional care most of the time, others being outpatients. In some, the investigations covered periods of deciduous dentition only, and some, the period of mixed dentition. Another variant may be the kind of food that made up the dietaries, for foods and food mixtures vary considerably in their influence on the calcium and phosphorus metabolism. Then the possibility of difference of opinion as to the absence or presence of rickets must be considered, as well as the broader belief that absence of symptoms of rickets is not positive proof of adequate vitamin-D intake.

Reports of balance studies by Koehne *et al.* (1934) indicate the possible harmful effects of refined sugar. They suggest that when persons are susceptible to caries, the regular use of diets rich in artificially sweetened food will generally exaggerate this tendency. Continuation of this line of research by Jay *et al.* (1936) with larger groups of children also showed that the consumption of unrestricted amounts of candy when the diet is otherwise inadequate will increase dental caries. No one has reported studies on a comprehensive number of children of the effects of quantity sugar consumption when the diet is adjudged adequate.

The principles of correct nutrition remain the same throughout the world, with variation only in sources of these nutrients in various sections. All investigators, Howe *et al.* (1933), Drain, Jones, etc., agree that a well-balanced diet is definitely favorable to arresting decay, whatever special importance they may attribute to one of the factors of such a diet, vitamin or mineral, or acid or base reaction. Some reports of lack of expected favorable results from single item additions may have failed to consider whether the diet was previously lacking in that item; the time interval or the number of cases. Drummond (1934), in an excellent critical review of nutrition, says, "In investigations on man one is dealing with individuals who perhaps for many years have suffered deficiency of vitamins or minerals and it cannot reasonably be expected that the effect of such chronic malnourishment will be dispersed by a few weeks' treatment with the factor concerned."

Despite the common knowledge of the importance of the early years, the preschool period from one to five years is the neglected age. Maternal and health centers usually care for the child only up to one year, then regular supervision ceases until the child reaches school. By this time, he is "damaged goods." Large numbers show some form of physical defect, and although there is no proof that all of these defects could have been avoided by improved feeding, there is evidence that many would not have developed. Deformed limbs, chest and head, badly formed or decayed teeth, running ears, septic tonsils and adenoids and simple goiters are seen in large numbers. It is at such a time, and in such condition, that the child is taken to the dentist. The crucial period, as far as influencing the fundamental tooth structure, has passed, but there is basis for believing that diet, after the initial formative period, may be important in the building of a resistant secondary dentin and in protecting the teeth in some yet unknown manner.

In planning diets for children, it is well to get a week's list of foods eaten. Next, one must consider the type of build of the child. The linear type with a slender body has a nervous temperament, a stomach slow to empty and shorter intestines, and needs more concentrated foods; whereas the lateral type, with a broad, chunky body, is placid and easy going, has a good appetite and needs bulky, low calorie foods. One must be careful about attributing body size to heredity, for very often it is merely the continuance of faulty habits of living from one generation to another which creates similarity. Then one must con-

sider other principles of nutrition such as fatigue and rest, regularity of meals and routine of living, as well as the mental attitude of the adults. Often, adults believe that, as their present diet seems to serve well, it is unnecessary to change; and their refusal to eat fruits, vegetables or other nutritious foods creates a problem for the imitative and impressionable child. Frequently, too, parents believe that nutrition workers overstress the value of the diet, since so few cases of easily recognized deficiency diseases occur. If lack of these nutrients were more complete and not simply partial, cooperation could be secured with ease.

The school lunch may be an additional problem. It frequently consists of sandwiches of meat and jam, a piece of cake or cooky and an apple. This high cereal-carbohydrate intake disbalances the best dietetic scheme. Many cereal products are very poor in vitamins and available mineral elements, and their inclusion in the diet limits the intake of milk and other protective foods. There is also evidence that they may be actually harmful in the sense that they increase the demand for vitamins A and D and calcium, and that their own calcium and phosphorus content are not available for the formation of bone in the growing organism under certain circumstances. Bread has so often been termed the "staff of life," but Dr. Hoobler (1928) says that, since cereals as now used are usually highly milled, the term should be changed to "the broken reed."

The reports by Clara M. Davis (1931) on the "self-selection" diet experiment in infants and young children erroneously promoted the idea that children could be allowed to eat anything they wished. The phrase "self-selection" impressed parents and dentists alike. Only the more observing noted that the list of foods from which the child might select contained no refined foods, milled cereals or sugar, nor food combinations which might contain these items, such as custards, puddings and cakes. Also, only breast-fed infants were used, so the subjects had not become accustomed to the taste of modern artificial foods.

With our present methods of living, and for practical social adaptation, we must adjust ourselves to a more usual outline of foods which are best used with regularity in order that there shall be no great gap in the child's nutrition. It is possible to maintain a well-balanced diet on a limited number of foods, but, in general, variety is more likely to supply all needed principles in combinations which assist utilization.

The child should be given a good start prenatally, then a lower cereal and refined sugar usage than customary should be advocated, beginning with the first supplements. There should be earlier inclusion of meat, including glandular portions, hard-cooked egg yolk, vegetables and fruits than has been the practice of physicians. The infant requires a proportionately higher protein intake. Quality is extremely important, and as breast-milk protein is so much more efficiently used than cow's milk, consumption of the latter must be greater during the period when the diet is almost exclusively milk of this type. It is to augment this protein that it is wise to include the other animal proteins of meat and egg early and to use them in quantity. Protein is the most important tissue-building food. Most standards have been set up by making diet studies of the protein eaten by children in orphanages or private home groups. The fallacy in this method lies in the fact that the amount eaten is definitely influenced by the amount offered, and it has not been customary to offer unlimited animal protein foods. Davis' study, wherein children were allowed as much food as they wished, shows higher protein intake than has been generally advocated. Wang (1928) found that, particularly with underweight children, a higher protein gives striking growth increases, and that the protein requirement is greater

than that of normal children. It is because of the desirability of maintaining a high efficient protein intake, not only because of mineral and vitamin content, that authorities recommend a daily quart of milk for children.

Energy needs increase as the activity of the child increases, so that, by the ages of eight to ten years, normal children should be eating as much food as the average sedentary adult, and, from this period, consistently greater quantities until growth is accomplished. Age, height and weight need to be considered in computing calories, and it has been thus estimated that for moderately active girls between the ages of six and sixteen, thirty-nine to forty calories per inch of height be used; before and after these years, thirty-five to thirty-seven calories. For boys, the data are insufficient to give a set standard per inch, but the needs are relatively higher throughout. Calories are important in that sufficient energy must be provided for growth and for the great muscular activity of children, but it is of greater importance that the foods supply the proper amounts of protein, vitamins and minerals.

Unfortunately, certain children show a lack of interest in food at the very time that their need is greatest. Studies by Wang *et al.* (June and December 1928) indicate that children take more food when factors such as irregular eating and bad home conditions are eliminated. Special care must be taken to be sure that no physical defect is responsible for the lack of appetite, and then methods for developing appetite must be undertaken. Often, supplementary vitamin B may be of value.

Well-controlled experiments by Daniels *et al.* (1934, 1935) suggest that if a child has previously been on a high mineral-vitamin diet, and has been in good health, one and one-half pints of milk daily up to five years of age can supply enough minerals for good nutrition, provided some mineral and efficient animal protein is given by other foods. After this age, one quart is best. Even so, Hunscher *et al.* (1935) reports that when the basal diet contained 1.9 gm. of calcium rather than the oft-quoted 1 gm., the approximate amount in one quart of milk, average retention was doubled. The rapidly developing child requires more minerals and vitamins than the more slowly growing, for the physiologic needs are then greater. Likewise, the child with chronic infections should be given foods rich in carotene or vitamin A in amounts larger than those usually prescribed, as utilization is lessened.

Only when the child takes milk with difficulty should schemes for hiding milk in foodstuffs be used. Ofttimes, a simple expedient, such as the use of cellophane straws, stimulates almost magically the drinking of milk. Calcium and phosphorus preparations should be given only in selected cases, but, when used for more than two weeks, a compound including both is necessary; for if the proportions of calcium and phosphorus are markedly altered by ingestion of one of these elements, the absorption of the other will be decreased.

Since school children do not develop rickets, it is often assumed that they do not require so much milk as in earlier years. But the bones are growing and calcifying rapidly and defective calcification of bones is shown by the ease with which they break. The frequency of bone fracture is a great social problem in some countries, especially in industrial countries. In an English public school where diet was closely controlled for twenty years, between 1919 and 1920, and 1928 and 1929, with a substantial increase in milk consumption, butter substituted for margarine and bread consumption decreased, there was an amazing increase in height and weight of the boys, but two other improvements in general condition were also observed: first, a great decrease in fracture of bones in accidents, and, second, a decrease in rheumatism and

rheumatic conditions. Many other reports of milk additions show a similar increase in height, weight, vitality and general health. Adding comparable calories in the form of sugar or biscuits did not produce similar growth and health; which indicates that something more than additional "energy food" was responsible for the results.

To assist in calcium-phosphorus metabolism, there should be regular and consistent use of a vitamin-D supplement, particularly during the growth period. Vitamin D milk offers a fine additional source. Such evidence as is available may be interpreted to show that cod liver oil, cod liver oil concentrate milk and irradiated milk are at least of equal potency for human beings, unit for unit. Vitamin D of animal source seems to be more potent for the human being than vitamin D of vegetable source (yeast milk or ergosterol). Some reports suggest that probably smaller dosages of vitamin D in irradiated milk form may be as adequate as larger doses of other forms. Tobey (1936) thinks that this seemingly efficacious action is due to an association between vitamin D and the milk protein (lactalbumin). There need be little concern as to the danger of excessive doses of any vitamin-D preparation. A series of tests on young rats showed that ten thousand to fifteen thousand times the therapeutic dose could be given without bringing about hypercalcemia.

In many sections, it is thought that vitamin D additions are superfluous because the sun activation will provide it in ample amount. Frawley (1931) found that there is a great variation in ultraviolet content of sunlight, depending on local climatic conditions. In central California, where there is an unusual amount of sunshine, this section being termed "the garden of the sun," there was a deficiency in the amount of ultraviolet rays. On account of the lessened proportion of ultraviolet rays to visible light rays and heat in sunshine, it is considered inadvisable in extremely hot climates to depend on sun baths for prevention and treatment of rickets, or to provide the sole source of vitamin D. Yet, inhabitants of areas subjected to long periods of sunshine may be expected to receive more vitamin activation than those in cooler zones.

The necessary changes in the diet of the child who has become accustomed to the common high intake of cereal and sugar foodstuffs should be introduced gradually. Nor should feeding problems be accentuated and established by insistence that the child eat every food offered. Too often, preparation of the foods is such that the flavor is strong or they are otherwise unappetizing. Many of the canned purees on the market are strong and salty, owing, no doubt, to concentration, and it is not strange that they are refused by a child who has had bland foods previously. Too rigid adherence to rules supposed to prevent loss of valuable minerals and vitamins in food preparation often defeats the original purpose by producing an unpalatable product. Sometimes, trial of several modes of preparation will produce one the child favors. At first, a certain amount of study and experimentation may be necessary to find the most acceptable forms. As a general rule, young children prefer unmixed foods. A child may take milk or tomato juice each alone, but refuses them when they are placed together in a soup mixture, though a cream sauce will sometimes make a vegetable acceptable because it dilutes the flavor.

It is a mistake to expect a child to take more than a taste of a new food the first time it is offered. Of course, there will be some who take immediately in quantity any new food; others who eat it only after seeing it several times. Again, a child may one day refuse foods that he has previously eaten with avidity. Many children refuse green foods such as peas, beans, spinach and asparagus, especially when served alone. It may be that green

SCHEMATIC ADAPTATION OF SUGGESTED DIETS FOR CHILDREN, SHOWING METHODS OF ADDITION TO A BASIC DIET*
Graded Additions (Each Added to Previous Total)

Basic for age: Protective Foods	9 Mo.-1 Yr. Amt.	Cal.	1-2 Yr. Amt.	Cal.	2-3 Yr. Amt.	Cal.	3-4 Yr. Amt.	Cal.	4-5 Yr. Amt.	Cal.	5-7 Yr. Amt.	Cal.	Total Accumulation		7-10 Yr. Amt.	Cal.	12-14 Yr. Total Amounts	Cal.
Milk (including cheese)	3 cups	498							½ cup	83	½ cup	83	4 cups	664			4 cups	664
Egg	1	74											1	74	½-1	35–74	1-2	74–150
Lean meat, fish, poultry	⅛-¼ cup	50			50								½ cup	100		50–100	3 servings lean (beef, chicken, etc.) or 2 servings medium fat (pork, salmon)	400–600
Fruit & vegetables:																		
Orange	1 medium	45											1	45			1 medium	45
High calorie fruit (½ banana, ½ cup apricots, 3 prunes, peaches, etc.)		90			45				45		45		2½ servings	225			2½-3 servings	225–270
High calorie vegetable (potato, peas, soy or lima beans)	⅓-½ cup	80			20		30				50		2 servings	180	½-½ cup	50–100	2-3 servings	160–240
Low calorie vegetables (tomato, greens, string beans, etc.)	2 servings of ¼-½ cup	20									10		2 servings	30			2-3 servings	30–45
Cod liver oil	1 tsp.	30							30		75		1 tsp.-1 tbsp. 235 1½-2 tbsp.				1 tsp.-1 tbsp.	30–100
Butter	½ tbsp.	50	½ tbsp.	50												75	2-4 tbsp.	200–400
Supplementary energy foods																		
Whole cereals, Breakfast cereal	½ cup	70											½ cup	70			1 cup	140
Bread (including rice, macaroni, cake, crackers, cookies, etc.)			1 slice	75							1 slice	75	2 slices	150	1 slice	75	3-4 slices	215–460
Sugar															1 tbsp.	50	2 tbsp.	100
Total		1,007		1,132		1,247		1,277		1,435		1,773		1,773		1,906–2,245		2,428–2,814

*Compiled 1937. The individual child may vary from 100 calories in the younger ages to 300-400 in the older. Do not permit the supplementary energy foods to substitute for the protective foods in fulfilling caloric requirement.

is not an attractive color to children. If mixing some mashed potato with them makes them acceptable, well and good; if not, those vegetables and fruits well taken, possibly white and sweet potatoes, carrots, apricots, peaches, prunes or bananas, should be used more often and more meat and fish added. These supply the same valuable minerals and vitamins found in green vegetables.

It is well for children to learn to eat all foods offered, but this is not accomplished by making an issue of food. Children do not demand frequent change and variety; in fact, they prefer bland, familiar foods. No doubt, this is one reason that cereals in all forms have usurped an increasingly large place in the dietary, and why potatoes can readily replace cereals. This does not mean that the same cereal and the same vegetables should be served each day. The various whole cereals may be alternated, likewise vegetables and fruits. But it is not necessary to spend a great deal of time in elaborate preparation of each food. Occasionally, custards, puddings or cocoa may be used; but as they contain sugar, they may initiate the refusal of unsweetened milk if given too frequently. The normal child will drink unsweetened milk during the progress of the meal, provided he has been started correctly. He intersperses milk with the other foods, often refusing solid foods before he has had a drink of milk, even during the weaning period. The alert adult in charge of the meals will be on the watch for indications of preferences in order of eating and will try to follow this procedure instead of her own ideas of proper order.

Generally, it is well to keep the sweet fruits and dessert back until the child has had an opportunity to eat a sufficient amount of the other foods, as there is no doubt that a number of children prefer sweets, and most children turn away from other foods for them. Cakes and desserts of all types other than fruits should be limited throughout the entire period of childhood. In the light of present knowledge, it seems unfortunate that menu habits demanding a dessert at both lunch and dinner have been so firmly established. It becomes increasingly difficult, therefore, to limit refined cereal and sugar intake to the proportionate amounts recommended by authorities.

Having reviewed nutritional information as it applies to childhood, we may make the following practical deductions and conclusions: Infants should preferably be breast-fed for approximately six months, with fresh fruit or vegetable juice for vitamin C and cod liver oil to provide vitamins A and D added, beginning about the second month. When artificial feeding is necessary, high carbohydrate additions should be avoided, and more fruit and vegetable supplements used. As the iron reserve of infants is small and milk is a poor source of this element, the early addition of a food high in iron content is recommended. Sieved hard boiled egg yolk can be added as early as the second month. Purees of green vegetables and carrots supply iron, and may be included at the fourth or fifth month. Cereals should be used sparingly, and then only in augmented or natural forms. Unless augmented cereals are used, vegetables are better for the first additions. The popular schedule of two-cereal feedings a day should be discouraged, potatoes, peas or bananas providing good substitutes for one feeding. Minced liver or scraped beef can be given from the seventh to the ninth month.

Most schedules call for midmorning and midafternoon feedings, even during the first year. If the child when weaned shows a disinclination for food and refuses to eat readily, the number of feedings should be reduced. Very frequently, the child, beginning at about seven to nine months, does better on a three-meal schedule, for he then has an opportunity to develop an appetite. Extra lunches may need to be added later when the child increases his activity.

*Compiled 1937. The individual child may vary from 100 calories in the younger ages to 300-400 in the older. Do not permit the supplementary energy foods to substitute for the protective foods in fulfilling caloric requirement.

From one to five years, the daily diet should include one and one-half pints of milk, one egg, meat (including liver) or fish, sweet or white potato, orange or some other high vitamin-C source, one other serving of fruit, two servings of vegetable, with green and yellow given preference, cereal in an amount not over the equivalent of two slices of bread, butter and cod liver oil.

A sample diet for the one-year-old child is as follows: Breakfast: One-half cup of whole cereal (which may have some milk added during the cooking); one cup of milk; the juice of one orange; one teaspoon of cod liver oil. Lunch: Baked potato (medium size); egg; cooked green vegetable; one cup of milk. Supper: Carrots or peas; meat (including liver) or fish; one serving fruit (either one-half banana, three prunes, 3 apricots or half peach); one cup milk.

After a sufficient number of teeth have erupted to permit chewing, raw fruits and vegetables, such as lettuce, celery, or carrots, are given.

Quantities served will need to be increased as the child grows older, but the general menu plan need not be changed. When the child reaches the age of five years, the milk is increased to one quart, and the vegetables increased so that there will be at least two servings of high-calorie vegetable and two servings of low-calorie vegetable, one of them raw, but the cereals are kept down to the equivalent of three slices of bread. An additional foodstuff at breakfast, either egg or bacon, a second fruit or a slice of bread, will benefit the rapidly growing, active child. There should be a gradual increase in quantity consumption as the child approaches adolescence and this increase should be maintained throughout this strenuous period.

If the interval between meals is too long because of family convenience, an after-school lunch of fruit or a cup of milk may be advisable, particularly for the adolescent. Too big a lunch at this hour or one of bread and jam dulls the appetite so that the evening meal is not eaten with relish. For the underweight child, a glass of warm milk at bedtime provides extra calories, and also promotes ready and sound sleep.

By following such a dietary scheme, the child is more likely to develop a sound body and teeth that are quite resistant to decay. If he is taught early to eat those foods which will supply the valuable minerals, vitamins and proteins, he will usually carry such habits with him throughout life, to the improvement of his nutritional condition and to the maintenance of a normal physiologic rhythm.

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L. PIERCE ANTHONY, Associate Editor

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Editorial Department

ONE OF THE REAL DELINQUENTS

IN the midst of all the censure in connection with the appalling neglect manifest everywhere when the condition of the teeth of children is under consideration, we seldom see reference to the greatest delinquent of all. Usually, the dentist comes in for a goodly share of the blame and probably a reasonable amount of responsibility may logically be laid at his door.

It surely would not be expected that the family physician could, on his own initiative, cope with the problem of caring for the teeth of children. In the first place, he has other problems that seem to him of greater moment, and, in the next place, he assuredly would not have the knowledge necessary to meet the situation without an extended course of study in the science and art of dentistry, a study that he certainly does not receive in his entire curriculum in the medical school.

Manifestly, if this problem is ever to be solved, it must be through the

medium of the dental profession, the only one through which it would ever be possible to solve it. This would seem to leave the sole responsibility squarely up to the dentist; but does it? Let us see. Supposing that the members of the dental profession should announce that, in the interests of common humanity, the defective tooth of every child in the land would be cared for regardless of the economics of the situation, how long would it be before the profession would be bankrupt?

In all conscience, the members of the profession, both in medicine and in dentistry, have always manifested an honest and philanthropic attitude toward the relief of suffering. We know of no case in which there has ever been a moment's hesitation on the part of a professional man to relieve suffering regardless of the patient's ability to pay. It has always been accepted as a fundamental obligation of the dentist to do this; but there is another side to the question.

When we begin to assess the responsibility for the proper protection and care of children, we should go back to fundamentals. Who is primarily responsible for the fact that children are in the world with their problems of ill health and disease? There is only one possible answer. It is the parent. It is not the professions, it is not society, it is not the children themselves. They had nothing whatever to do with it.

Every parent who brings a child into the world is under a rigid moral obligation to care for that child up to the years of accountability. If this is not fundamental, there is nothing fundamental in all human relationships. It is the duty of parents to promote the welfare of their children physically, and—to the extent of their ability to do so—mentally and morally. It is the evasion of this responsibility that is at the bottom of most of our complications and handicaps with children, and this means the physical handicap of tooth decay as well as any other handicap.

Till we can educate parents to a sense of their obligation in the situation, we shall never cure the ills of children. It will not avail to hedge behind the plea of inability on the part of parents to take proper care of their children. The great lesson of life, the one that needs to be taught beyond anything else, is that of individual and parental responsibility, and till the time comes that we can instil this idea into the minds and hearts of the people, we shall not go very far toward solving the problems of childhood, and this really means the problems of life generally.

Basically then, the real delinquent in the present appalling situation connected with the condition of the teeth of children is the parent. Till parents can be impressed with their legitimate obligations to their chil-

dren, we shall never see children properly cared for, and, to carry the idea a step farther, it will not solve the situation to foster the idea that if parents find it difficult to perform their legitimate function of properly providing for their children, the obligation should be passed on to some one else who will assume the obligation. Vicarious responsibility is in every way demoralizing.

The habit of passing responsibility to other people, when other people are in no way under obligation to do anything in the matter, has become one of the stock methods of "getting out from under," and it has led to much loose thinking and, what is worse, it has, under certain circumstances, led to actions that are open to censure and in no way constructive or commendable.

Humanity up to the present time has been slow to insist that parenthood involves a very serious and very intimate obligation.

Fortunately, the natural love and affection that parents usually have for their children tends to protect the child in most respects; but it does not go far enough. It never occurs to the average parent that he should be held to strict accountability for any physical handicap to his child, particularly if that handicap is preventable. The real obligation of parenthood has never been properly appraised.

What right has a parent to assume that if he finds it difficult to take care of his child, some outside agency must step into the breach and relieve him of his obligation? Again, the seriousness of parenthood has never been sufficiently impressed on society.

Woe betide the parent who wilfully condemns a child to a life of misery through neglect. The sense of responsibility with many parents grows painfully thin as soon as they are called on to make any major sacrifice for the welfare of their children, and the only way to compel a proper observance of the parent's duty in this regard is through the medium of the law.

Laws are made to protect against contagious diseases, and properly so. Not till we make laws against the appalling limitations placed on our children by needless neglect shall the children be saved from the consequences of neglect. If parents will not voluntarily care for their children, they should be compelled to do so and by law.

Visionary? Yes, but most forward looking ideas were merely a vision before they were forced into practice by the insistent urge of a great need.

GREATER NEW YORK DENTAL MEETING 1937

Now in its fourteenth year, the annual Greater New York Dental Meeting has become an institution in dentistry that is looked forward to each year by practically the whole of the profession along the Atlantic seaboard with anticipations of benefit and pleasure. And on none of these occasions within our knowledge have the numerous seekers for the latest in post-graduate knowledge been disappointed.

The recent meeting held at the Pennsylvania Hotel in New York City, December 6 to 10, 1937, was, even under the stress of recessional tendencies, one of the most successful of these meetings held in recent years. And when we say successful, we mean that some seven thousand attended the meeting and many over a thousand were registered for the educational clinics.

On Monday, preceding the purely dental features, the Seventh Annual Combined Medical-Dental Meeting was held under the auspices of the Joint Committee of the Organized Medical and Dental Professions of Greater New York. This joint meeting has become an annual feature of the Greater New York Dental Meeting, and has been conspicuously instrumental in promoting a closer cooperation and understanding between the medical and dental professions of the great metropolis, the purpose for which the movement was organized.

Monday evening was devoted to the first general session of the dental meeting proper, and was signalized by addresses from the President of the American Dental Association, Dr. C. Willard Camalier, Washington, D. C., Dr. Edwin I. Harrington, President of the New York State Dental Society, Dr. John L. Rice, Commissioner of Health of the City of New York, and Dr. Harold G. Campbell, Superintendent of Schools of the City of New York. The keynote of the addresses of these eminent speakers was the promotion of the theme of President Camalier, "Dental Health for American Youth," the working motif of the American Dental Association under his administration. Both the Commissioner of Health and the Superintendent of Schools of New York City expressed interest in the plan now in operation for the dental health of the children of New York City and offered some helpfully constructive suggestions whereby health and particularly dental health education may readily be incorporated in the general educational program of the entire country.

Each afternoon scientific sessions were held at which nationally known speakers presented all the scientific aspects of dental practice and these

were followed by the continuous clinics which elaborated all the clinical phases of practice.

The mornings were given over to Topic Discussions which were well-conducted round table discussions of pertinent questions involved in each and every phase of dental practice, directed by leaders particularly fitted for the teaching of each of the several phases of practice. These Topic Discussions have developed into a most instructive feature of the Greater New York Meeting and this year attracted much enthusiastic interest and attention. It is at these discussions that the specialist or the general practitioner can receive collaborative help from the leaders in solving his most difficult problems.

In addition to the abundant educational pabulum served to its guests, the Meeting offered two attractive and entertaining diversions, the Alumni Luncheon on Wednesday afternoon and the Jamboree on Wednesday Night.

This and the other two large meetings of the year, the American Dental Association in the summer season, and the Chicago Dental Society in February, are an earnest of the perennial interest which the dental profession maintains in the advancement of all phases of dental practice, and the eminent success of the latest Greater New York Meeting is certainly a tribute to the enthusiasm and directive ability of the officers and committees of the Greater New York Meeting under the most capable leadership of their genial Chairman, Dr. Waldo H. Mork.

While preventive dentistry, directed particularly to the health of the community, received considerable attention on the program of the meeting, restorative dentistry—bridgework, partial dentures, full dentures, immediate denture service—received the lion's share of attention. All phases of constructive work were presented, particularly denture service, the latter as a necessary consequence of the medico-dental indiscriminate tooth removal hysteria caused by the fear of oral focal infection.

Another reaction from this extraction fad that is apparent is the sign of return to rational, conservative procedures as embodied in the operation for pulp removal and root-canal filling in preserving the teeth for reconstructive aids.

Pulp-canal treatment received considerable attention, and we noted with much satisfaction an enlightening contribution to the subject by Dr. Alfred Walker, who has throughout the oral focal infection period remained steadfast in his belief in the possibility and desirability of saving the pulpless tooth when and where advisable. We believe this incident and others of a similar nature at recent meetings mark the turn from the

radical procedures, aided and abetted by the medical men, which threatened the very foundations of dental practice.

The mission of dentistry is to save teeth rather than remove them, and if we cannot save teeth under reasonably favorable circumstances, then dentistry has failed in its main avowed purpose. We have never believed, nor do we now believe, that dentistry has thus failed; on the contrary, evidence is daily accumulating to strengthen our faith in the operation to save the pulpless tooth, and thus go far toward preserving the normal and healthful unity of the masticatory apparatus.

L. P. A.

OBITUARIES

ARTHUR D. BLACK
(1870-1937)
(See Frontispiece)

ARTHUR DAVENPORT BLACK, born in Jacksonville, Ill., November 15, 1870, the son of G. V. Black, prominent educator and scientist in the dental field and known as "The Father of Modern Dentistry," died December 7 after an extended illness.

Dr. Black had been for twenty years the dean of the Northwestern University Dental School, holding that position up to the time of his death, and was himself widely known as an educator, scientist and writer. He was a graduate of Illinois College and of the Northwestern University Dental School, class of 1900. One year later, he received the M.D. degree from the Northwestern University Medical School. In addition, he held the degrees of master of arts and doctor of science, and was a member of the honorary fraternities of Phi Beta Kappa, Alpha Omega Alpha and Omicron Kappa Upsilon, as well as of Delta Sigma Delta. In June 1937, he was awarded the Alumni Medal for his distinguished services to the university, the highest award in the power of the alumni association.

Dr. Black had been a member of the faculty of the Northwestern University Dental School since 1900, as professor of oral surgery, of operative dentistry and of oral pathology. He served on the staff of St. Luke's Hospital for twelve years. He was a member of the American Dental Association, the American Medical Association and the Institute of Medicine, a director of the Chicago Tuberculosis Institute and a Fellow of the American College of Surgeons and of the American College of Dentists. He held honorary membership in many scientific societies both in America and abroad (including the Royal Society of Medicine of England, the German Academy of Natural Sciences and the Swedish Dental Society). During the World War, he was advisor to the Surgeon General of the Army, in Washington. At the time of his death, he held a commission as colonel in the Reserve Corps.

Dr. Black aided materially in the reorganization of the Illinois State Dental Society, devising a system which has been widely adopted in other states and which has served as the basis for the development of the American Dental Association to its present form. During the Century of Progress Exposition, he designed and directed the special dental exhibit and was president of the Chicago

Centennial Dental Congress, the largest dental meeting ever held in the world.

Among the many honors that came to Dr. Black were the presidency of the Illinois State Dental Society, of the American Institute of Dental Teachers and of the International Association for Dental Research and membership on the National Research Council. He was the author of the Index of Periodical Dental Literature, consisting of thirteen volumes, from 1839 to date; of a classic text on operative dentistry, in four volumes, and of more than two hundred scientific articles in medical and dental literature. His research studies in the field of focal infection and of diseases of the gums were especially important, and during the last five years, significant studies on the cause of dental decay have been carried out under his direction.

Dr. Black's greatest achievement was in dental education. As dean of Northwestern University Dental School, he established the first dental clinic for children and organized the first successful department of graduate study in dentistry. He designed much of the building and special equipment of the present dental school in the Montgomery Ward Memorial Building, introducing many new ideas which are accepted as standard today. He was very active in the American Association of Dental Schools and was a member of the Curriculum Survey Committee, which has recently completed an important study of dental education. In addition to his influence on dentistry and dental education in the United States, he did much to establish friendly relations with the profession of other countries.

Dr. Black was married to Amelia Bronaugh, of Virden, Ill., October 19, 1897, who survives him, with their three children, Gilmer V., Mary Barbara Dunbar and Jane Van Doren. Carl E. Black, surgeon, of Jacksonville, Ill., and two sisters, Miss Clara Black, of Evanston, and Mrs. Mark Baldwin, of Duluth, Minn. also survive.

GEORGE NELSON WEST
(1864-1937)

Died, at his home in Chicago after a short illness, October 3, 1937, George Nelson West, D.D.S.

Dr. West was born on November 26, 1864, the son of Nelson and Tamson (Jainison) West. His preliminary education was received in Chicago, and he was graduated from the Chicago College of Dental Surgery in the class of 1887. Later, he was associated with that institution for seven years as a member of the faculty.

Through a period of many years, Dr. West was active in various dental organizations. He was a member of the Chicago Dental Society, the Illinois State Dental Society and the American Dental Association. In the Chicago Dental Society, he served a term as secretary and, in 1913-1914, was president. He was a member of Delta Sigma Delta for nearly fifty years and had held many high offices in that fraternity.

Dr. West, early in his career, served as chairman of the Laws and Infractions Committee and did much to raise the standards of the dental profession. He was also of outstanding service in the drafting of an early dental practice act, and had been continually interested in improving the standing of his profession.

The passing of Dr. West is sincerely mourned by all of his friends and colleagues. This is true because within himself he had a large store of those qualities which are essential to friendship and leadership: loyalty, devotion, sincerity and a gentle humor. His unselfish devotion to the affairs of organized dentistry; his endeavor to lift the standards of a growing profession; his many contributions as a member and as a leader—all marked him as one who richly deserves to be remembered as a man who has left his impression on dentistry.

In 1898, he married Miss Anna S. Brown, of Florence, Ala., who, with two sons, survives him.

ASSOCIATION ACTIVITIES

COMMITTEE ON LEGISLATION

THE "mail order denture" racket has been severely condemned by the dental profession for its pretenses, representations and promises that are without truth, but has enabled those engaged in this business of exploiting the gullible to continue profitably a racket that is condemned by all honest dental practitioners and should be outlawed by every federal and state law enforcing body.

The Federal Trade Commission has forbidden these concerns to continue to make certain claims for their product, commonly used in their advertisements, but branded as untrue, false and fraudulent by the commission.

Recently, the Federal Post Office Department set a trial in Washington, D. C., for S. B. Heininger, of Chicago, whose license to practice dentistry was revoked last May by the Illinois Department of Registration and Education, to show cause why a fraud order should not be issued against him.

William C. O'Brien of the U. S. Post Office Department signed the charges, copy of which follows. George F. Breen, representing the Solicitor of the Department, presented the evidence at the hearing before Judge Kelvin W. Hassell in Washington, November 24, 26 and 27.

Witnesses who testified for the government were P. H. Harper, of the U. S. Public Health Department, one dental officer from the Navy and L. G. Jordan, professor of prosthetics, Georgetown University, Maryland. Dr. Jordan used 150 lantern slides to illustrate the necessary technic employed in the taking of a proper impression and the fitting of a finished denture. At time of writing, the decision of the court in this case has not been declared.

A. B. PATTERSON, D.D.S.,
Joliet, Ill.,
Chairman, Committee on Legislation,
American Dental Association

(COPY)

September 22, 1937

In the Matter of charges
That
DR. S. B. HEININGER,
DR. S. B. HEININGER, D.D.S.,
DR. S. B. HEININGER, Dentist
DR. HEININGER, and
SYLVAN DENTAL
LABORATORY,
at
CHICAGO, ILLINOIS,

are engaged in conducting a scheme for obtaining money through the mails by means of false and fraudulent pretenses, representations and promises, in violation of 39 U. S. Code 259 and 732 (Sections 3929 and 4041 of the Revised Statutes, as amended).

MEMORANDUM recommending the issuance of a citation to show cause why a fraud order should not be issued.

It is charged that the above-named concern and party are engaged in conducting a scheme for obtaining money through the mails by means of false and fraudulent pretenses, representations and promises, in violation of 39 U. S. Code 259 and 732 (Sections 3929 and 4041 of the Revised Statutes, as amended), which said scheme is in substance and effect as follows:

Said concern and party are obtaining and attempting to obtain various remittances of money through the mails from divers persons for so called false teeth, dentures or "plates" upon pretenses, representations and promises made in advertisements and in written and

printed matter sent through the mails to the effect:

That said false teeth, dentures, or "plates" will restore to any purchasee thereof full power of mastication and enable him to chew and eat anything with perfect ease and comfort;

That said false teeth, dentures or plates are very beautiful, natural looking and attractive;

That said false teeth, dentures or plates will fit any purchasers thereof perfectly and give real complete glorious perfect ease, comfort, satisfaction in every way for life.

That said false teeth, dentures or plates will enable any purchasers thereof to laugh with ease, smile with ease and talk with ease;

That the foregoing representations will be fulfilled under all possible conceivable conditions and with every possible type of mouth, including those where because of certain oral peculiarities dentists have stated it is not possible to have well fitting teeth;

That no experience is necessary to make your own impressions;

That each and every set of false teeth, dentures or "plates" sold by said concern and party is made under the personal supervision and direction of Dr. Heininger;

That said false teeth, dentures or plates are of the very highest quality, the finest that can be procured anywhere, and that there cannot be any better fitting teeth;

That any person purchasing said false teeth, dentures or "plates" will obtain therefrom the same high degree of utility, improvement of appearance, perfection of fit, life long comfort and satisfaction and other advantages alleged to have been obtained by individuals, purported copies of testimonials from whom are set forth in the advertising and circular matter of said concern and party; and

That every purported copy of a testimonial letter appearing in the circular matter of said concern and party is absolutely true.

Whereas, in truth and in fact, as said concern and party well know, all of the aforesaid pretenses, representations and promises are false and fraudulent.

I therefore recommend that said concern and party be called upon to show cause why a fraud order should not be issued against them.

WILLIAM C. O'BRIEN,
Attorney.

To the Solicitor
of the Post Office Department
Washington, D. C.

DEDUCTION OF MEDICAL-DENTAL EXPENSE FROM INCOME TAX

THE American Dental Association has officially endorsed in principle that provision of S. 2997 which seeks to amend the Revenue Act of 1936, to allow medical-dental expense to be credited against the income of individuals for income tax purposes.

It would appear that expenses incurred in the medical-dental health care of a family is a just and proper deductible item and many obvious arguments could be advanced in favor of this proposal. It is believed that its merit will be generally recognized and that favorable action will be taken by Congress.

S. 2997

In the Senate of the United States, August 20 (calendar day, August 21), 1937, Mr. Bone introduced the following bill; which was read twice and referred to the Committee on Finance:

A BILL

To allow certain credits against the income of individuals for income-tax purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, that section 25 (b) of the Revenue Act of 1936 is amended by adding at the end thereof the following new paragraphs:

"(4) Credit for Education of Dependents.—Any reasonable and normal amounts actually paid during the taxable year for the education of a dependent, other than husband or wife, receiving his chief support from the taxpayer, if such dependent is less than twenty-one years old.

"(5) Credit for Medical and Dental Expenses.—Any amounts actually paid during the taxable year for medical, dental, surgical, or nursing treatment or hospitalization of the taxpayer or his spouse or any dependent for whom a credit is allowed under paragraph (2) of this subsection: *Provided,* that the total amount deductible under this subsection by any individual in any taxable year shall not exceed $250.

"(6) Credit for Funeral Expenses.—Any amounts actually paid during the taxable year for the funeral and burial of a taxpayer's husband or wife, or a dependent for whom a credit is allowed under paragraph (2) of this subsection: *Provided,* that no deduction shall be allowed under this paragraph if at the time of filing of the return such expenses have been claimed as a deduction for estate-tax purposes in an estate-tax return."

SEC. 2. The amendment made by this Act shall apply with respect to taxable years beginning after December 31, 1937.

DO YOU RECOGNIZE THIS DENTURE?

THE authorities in Dutchess County, New York, are endeavoring to ascertain the identity of a body recently found in the vicinity of Poughkeepsie, N. Y. Apparently the only means of identification is an upper vulcanite denture. Dentists are urgently requested to check their files in an effort to help establish identification. The following information is furnished by the office of the district attorney:

Fig. 1.—Front view of denture. The right central incisor, which had been removed for purposes of identification, was temporarily replaced for photographing.

A full upper vulcanite denture. Made of maroon vulcanite for the palate and plain pink for the labial. (Fig. 1.) The pink vulcanite is not reinforced or backed up by the maroon. Palatal relief area was probably formed by a piece of Spence or relief metal. Definitely a high vault and a tapering arch. Cast has been scraped for retention of plate. Peripheral beading around entire border of plate. Double line of beading around postdam area. (Fig. 2.) Postdam area scraped in two lines. Two swaged shell crowns of gold, upper right and left cuspids. Teeth, Justi mould No. 225, shade 3D. Double postdam and relief chamber on palatal surface.

Fig. 2.—Posterior palatal view.

Also bead around the periphery extending all the way around the palatal surface of denture. Plate appears to be of some age; over a year old, approximately not more than four years old. Gold plated pins in teeth.

The wearer was probably a very heavy user of tobacco.

If you have a record of such a plate having been made by you, will you please communicate with this office immediately.

ELY L. GELLERT,
Assistant District Attorney,
Court House,
Poughkeepsie, N. Y.

BUREAU OF PUBLIC RELATIONS

COMMUNITY MOUTH HYGIENE

By H. Shirley Dwyer, D.D.S., New York City

OUR educational system in this country has undergone a steady change in thought. The past three or four decades, influenced as they have been by changing social, industrial and economic conditions, have witnessed very marked and rapid widening of the horizons of the teaching profession. From the old idea which "assumed that the salvation of the soul and the development of the mind were dependent on the debasement of the body, the greater part of the teaching profession of today has broadened its horizon and redefined its objectives to include the whole child with all his needs for education." With this more inclusive interest on the part of education naturally comes a greater interest and changed relationship in regard to the health of the child. Again the broadening influence of the newer objectives in education manifest themselves in a changing concept of what constitutes a community health program, as well as the methods of presenting health material to the school child.

From a rather critical perusal of many of our most recent as well as long established plans for community dental health and community mouth hygiene, we are led to wonder whether dentistry has kept pace with progress. Are we not permitting the immediate and visible results of dental caries to cast long, distorting shadows across the broader horizon of the mental, physical and spiritual as well as oral welfare of the child? That is one reason why the subject of this paper is community mouth hygiene rather than community dentistry.

Hygiene is defined as "that branch of medical science that relates to the preservation of health." Mouth hygiene, then, would be that branch of medical science which relates to such salutary oral practices as contribute to the preservation of health.

If we are willing to accept these two definitions, we may set up as the true objective of a program of community mouth hygiene the adoption of such salutary oral practices as contribute to the preservation of the health of the community.

With this positive objective, we must realize the necessity of broadening our horizons and increasing the scope of our influence beyond mere operative intervention in the mouth.

Such an objective is a challenge to the profession of dentistry, a challenge which should lift us from our lethargic satisfaction over having made so many school inspections showing thus and so many carious teeth per child. For instance, an excellent paper appearing in the November issue of The Journal consumes sixteen pages with figures on the dental condition of Illinois school children. Again, let us take as an example one of the greatest cities in the United States where the paper mill of departmental statistics daily grind out: number of patients registered; number of carious cavities; number of pits and fissures; number of other operations, and so on *ad infinitum*. These figures and the conditions which they rep-

(Read before the Greater New York December Meeting, December 1936.)

resent have their place in determining the extent and cost and operative success of the service portion of a program, but they do not for one moment represent an answer to the challenge of true community mouth hygiene. It is time that the officials responsible for such programs awake to the fact that while they may be giving excellent service, they are getting nowhere in the broader field of community mouth hygiene.

The organization and proper functioning of a mouth hygiene program necessitates the inclusion in its activities of two major divisions: education and service. That this statement be not considered as merely my opinion, I quote a noted authority on public health, Donald B. Armstrong, who, writing about New York City, says:

> Since the responsibility for the medical and nursing aspect of this work in New York City is centered in the Department of Health, the solution of these problems rests upon it. For those tasks in the health education field or those demanding the participation of principals and teachers in the school health work, the Department of Education must take the responsibility.

The educational phase can succeed in some communities without the aid of the service program, but a service program unaided by education will never succeed except in perpetuating itself. Unfortunately, all over this country and abroad, these two complementary programs are being used separately, and the proponents of each fail to recognize the necessity of combining the two phases.

Today, I propose to discuss and compare the two types or phases which are at present so largely employed separately as dental programs, and, by a brief but critical comparison, perhaps clear the way for a better understanding of what should constitute a real mouth hygiene program.

Community mouth hygiene is essentially a problem of education and therefore belongs in the field of education.

A community dental program, on the other hand, is essentially a service program concerned with operative intervention along preventive lines, and therefore is in the field of public health.

Immediately we realize that there must be a difference of sponsorship of two types. Sally Lucas Jean, noted health educator, writes: "The school health program consists of service, hygienic environment and sound instruction." To accomplish this end means the perfect cooperation of the two departments of health and education. How often, however, does each department assume its proper share of the burden?

Let us take as an example the State of New York, one of the few states where the dental program is under the direction of the department of education. The New York State Department of Education correctly interprets this to indicate that its responsibility is that of preparing and executing an educational program; and it is doing so. Only recently, a dentist, Dr. McNeely, of the Department, has been appointed to the board of regents as an advisor on dental education for school children. The New York State Department of Education is working out an excellent educational program for this state, and one in complete accord with recognized organized dentistry.

What of the service program? Certainly a service program, when necessary, should not be saddled on the educational authorities. It does not belong there, and, in some states, such a situation has legal complications. It is definitely the responsibility of the forces of education to so direct the processes of learning that the child, and through him the parent, arrives at a state of awareness of the necessity of the acquisition of health and the individual's own responsibility for its maintenance. They should have absolutely nothing to do with service: that is a function of the department of health, and in New York State that means that it is not the case as far as dentistry is concerned.

Consider a directly opposite situation, here in New York City. The New York City Health Department conducts one of the finest service programs in the world, but is it educational? It is not. It gives instruction, yes; but that is not education. This is as it should be for a service program. That there may be no misinterpretation of my statements, let us consider the definitions of "instruction" and "education":

Instruction—Imparted knowledge; the act of instructing.

Education—The systematic development and cultivation of the natural powers, by inculcation, example, etc.

"Instruction" would relate to the single or infrequent exposure as is the case when a dental hygienist or nurse gives a classroom talk. This is not educational and is not considered good teaching. Dr. Smiley, of the New York State Department of Education, states this fact as follows: "The complete segregation of all health teaching to two short recitation periods a week, we have already characterized as inefficient health pedagogy."

"Education" refers to the more fundamental methods of establishing a desirable hierarchy of habits, proper ideals, useful skill, etc., through the work of the classroom teacher and dental hygiene teacher.

Then what of the educational program? The Department of Education cooperates with the Department of Health through its demand for completion slips showing corrections made. Here again is an example of a department seeing only the immediate gain as obtained through service, and completely overlooking the opportunity of balancing the service program with an equally thorough educational one. Now remember my earlier statement: A service program unaided by education succeeds only in perpetuating itself. True, there are certain teachers designated as health councilors whose duty it is to guide the teachers in their health work, but the actual teaching of mouth hygiene by a classroom teacher in New York City is practically nil. Yet it can be done. The Oral Hygiene Committee of Greater New York proved that a few years ago when it sponsored a highly successful teaching program in five New York City Schools.

It is also interesting to remember that the weaker the educational program, the greater the demand for a service program. This statement may lack full significance until we understand better the objectives of an educational program. One of the major objectives of all education is the making of better citizens. Let me quote from what the Commission on the Reorganization of Secondary Education lists as the objectives of secondary education: "(1) health; (2) command of the fundamental process, such as reading and writing; (3) worthy home membership; (4) civic participation; (5) worthy use of leisure; (6) ethical character; (7) vocation." Therefore, with a proper educational balance to the program, the child is brought to a realization not only of his dental defects—that is merely a detail—but also of the necessity of caring for his health as his own responsibility. Again I say: Dentistry broadens our horizon. Is our ultimate goal to be the mere correction of dental defects, or is it the building of better citizens, trained to assume the responsibility of maintaining themselves in a state of health? The less the educational training in self-reliance and responsibility, the greater the dependence on governmental paternalism in the form of clinics. Which would you perfer?

I stated earlier that the educational type of program may succeed without the aid of a service program. This is no Utopian dream, but a demonstrable fact. Let us take as an example an excellent report from a school in Valley Stream, N. Y.:

1929-1930, 187 permanent teeth requiring extraction.

1935-1936, 18 permanent teeth requiring extraction.

1929-1930, more than 170 cases of inflamed gums.

1935-1936, more than 40 cases of inflamed gums.

1929-1930, less than fifty children with mouths OK.

1935-1936, nearly 270 children with mouths OK.

There are about 600 children in this school. The credit for this work belongs to a dental hygiene teacher and to the principal and teaching staff for their excellent cooperation. A second report, also excellent, is from two schools in Bellrose-Floral Park District:

First school:

1931-1932, 20 per cent of the children received dental correction.

1936, 45 per cent of the children received dental correction.

1931-1932, there were 5.5 cavities per child.

1936, there were 1.5 cavities per child.

Second school:

1931-1932, 16 per cent of the children had dental corrections.

1936, 42 per cent of the children had dental corrections.

1931-1932, 7.0 cavities per child.

1936, 2.4 cavities per child.

Again I point out that this was accomplished through educational work only—no service program; and again I credit this to the excellent work of the dental hygiene teachers, the inspiration of their supervisor and excellent cooperation of their teaching associates. The figures quoted from reports of these three schools are being duplicated in many other communities where dental hygiene teachers are employed and strictly educational methods are used in carrying out the health program.

Lest it be thought that this work can be successful only in rural communities, I quote from the reported results of a five months' experimental program sponsored in New York City by the Oral Hygiene Committee of Greater New York. This program was carried out through the work of the classroom teachers alone. They were guided by an expert health educator and a dentist, but the actual working out of the program was entirely in the hands of the grade teacher. In a five months' period, dental corrections were raised to as high as 89 per cent correct mouth conditions in one class, with average corrections for an entire school of 59 per cent. This was all accomplished without the benefit of a clinic or low fee dental service, and the economic standing of that particular section of New York City would place it in the low-wage white collar class. One more school on Long Island must be mentioned because of its excellent record, a school in the west end of Long Beach with an enrollment of 489. In 1936, it reported 100 per cent corrections, 74 per cent of these corrections being made by private dentists.

It may have been observed by now that I have been quoting correction figures. That has been done solely because, in a paper of this kind, the intangible health and educational values of a program are so difficult to record. However, let me again quote from the final report of our five months' experimental program as to the results:

> Every child and teacher completed the special study on teeth pleasurably "tooth conscious." They learned that children's first teeth are important.
>
> They learned how and why and when teeth should be brushed, and brushed them.
>
> They learned the proper food to grow strong teeth.
>
> They learned the necessity of a regular and thorough check up of their teeth by the dentist. They learned to go early to him and have the work done early.

Best of all, they learned that they were personally responsible for their own health and that the care of their health involved a monetary responsibility to the dentist or physician whose services they obtained.

It is not my intention to go into the economic results of these programs, but it might not be amiss for all of us to con-

sider what such a program must mean in office returns to the dentists in those communities. If we could only realize it, we have much for which to thank our friends and co-workers, the dental hygienists, especially when we consider that all of these figures were taken from depression years.

So much for the educational phase. Let us consider briefly the service type of program.

First, what are its objectives? Obviously, dental correction. When the correction is accomplished, the case is terminated, and the patient becomes conscious of his oral condition again only when in pain or on recall for service. Any one who has had actual experience in even a well-organized dental clinic knows how little, if any, opportunity exists for instructional work at the chair. In the first place, the child's mind is not in a receptive condition: he is usually frightened. Secondly, the child is not in his accustomed educational environment, his classroom. Lastly, the operator has neither the time nor training to make instruction possible.

The lack of an educational training fitted to the broader objectives is the outstanding characteristic of all service type programs. Even such programs as the Strusser plan and its twin brother, as published in a recent edition of the *Dental Outlook*, entirely overlook the necessity and advisability of including a basic educational program as part of their plan. Instruction in toothbrushing is mentioned, it is true; but this is not educational: it is merely instructive and does not conform to the fundamentals of teaching.

It would be obviously unfair to attempt to compare the results of a service plan and those of an educational one. Just one point will have to suffice: Neither the service program of New York City—and it is an excellent one—nor the service plan of the Junior Red Cross outside the city has succeeded in reducing the incidence of uncorrected dental caries of children entering school; whereas the records previously quoted for educational work show marked improvement over a comparatively short time.

One other item which must not be overlooked is the cost to the community. The annual reports of two educational programs, exclusive of salary, show an average cost of $22 to $25 per year. A good service program exclusive of salaries cannot be maintained for much under $20.00 per month for each clinic for supplies alone.

These statements and comparisons have not been made to disparage the service plan, but merely to point out that it is just a small part of a complete mouth hygiene program, and should never be accepted by any community as a complete answer to the community's dental needs.

So far, we have considered the two phases of a mouth hygiene program separately. Let us sum up the principal weaknesses of each.

The educational phase may create the desire for health measures which economic conditions prohibit without some form of free or low-fee service for the indigent.

The service phase furnishes free or low-fee service without motivating the child to seek health facilities and leading him to an appreciation of their value.

A combination of the two phases, with the educational assuming the major responsibility of creating a community mouth hygiene program, would overcome all of these objections. The profession itself, however, must actively enter into and be responsible for a definite share of the working of any program. For any health officer to attempt to work out a program without the active participation of the profession means failure.

It was my privilege two or three years ago to outline for a private group of commercial interests a state-wide program including these phases. Unfortunately, the lack of understanding of professional ethics on the part of commercial friends made it impossible to proceed with the

program. We submit this program in brief, not in detail, as a possible start in what seems to be the right direction.

OUTLINE OF COMMUNITY MOUTH HYGIENE PROGRAM

The administration of this program is to be vested in a board composed of representatives of the department of education, department of health and the recognized dental societies. The director of the board should be a suitably qualified dentist, preferably with a public health and health education background.

1. *Educational Phase.*—This phase is to consist of:

A. A fundamental educational program in the elementary and secondary schools in mouth hygiene, suitably integrated with other subjects of the curriculum.

B. Accredited summer school courses in the essentials of mouth health for teachers, nurses and other school workers interested.

C. Accredited courses of study in the normal schools covering the essentials of mouth health.

2. *Service Phase.*—This phase is to be entirely under the direction and guidance of the health department as to policies, the department acting with the advice of the dental profession. Any cooperating agencies would of necessity have to conform to these policies.

3. *Professional Activities.*—These activities are the following:

A. Through the use of the county or district societies, the offering of postgraduate courses in dentistry-for-children.

B. Issuance of certificates of proficiency to members completing the postgraduate courses.

C. Cooperation with the department of education in the preparation of source material in dental health for teachers.

D. Preparation by professional groups such as oral hygiene committees and public relations committees, in collaboration with the educational groups, of dental educational material for lay consumption.

I do not propose to enter into any of the details of this program, which were discussed and accepted; but a brief consideration of it will reveal that it fulfils all the requirements of a community mouth hygiene program in that it stresses most heavily the educational phase as regards profession, teachers and children; provides for the use of a service program where necessary, and definitely commits the dental profession itself to active participation in the plan.

The objective of such a program is not the limited field of mere dental correction, but the broader view of a populace thoroughly imbued with health knowledge, health ideals and an understanding of their own responsibility in the maintenance of health, and something of its value.

This program was outlined, as it stands, in 1933.

It is time that our profession as a whole interest itself more actively in the health problems of the community. Probably no other profession can justly boast of a more rapid advance in technical skill and scientific accomplishment than the dental profession. The period of initial growth from artisan to professional status is now a thing of the past. We have turned again toward our mother profession of medicine, and it is fitting that, with the elevated standing now occupied by us, we should assume the responsibility of a greater interest in social problems. Let our goal be one of the aims of health education: "To improve the individual and community life of the future; to insure a better second generation, and a still better third generation; a healthier and fitter nation and race."

THE 1937 EDUCATIONAL EXHIBIT OF THE PENNSYLVANIA STATE DENTAL SOCIETY

By I. Franklin Miller, M.A., D.D.S.; Robert T. Hance, Ph.D., and Olive O. Harris, B.A., Pittsburgh, Pa.

FOR the first time in its history, the Pennsylvania State Dental Society allocated a substantial sum of money to permit the staging of an adequate educational exhibit at its May meetings. Lacking the precedent of past demonstrations, the committee had to depend in part on the experience of one of them in setting up displays intended to picture the phenomena of living activities and in part on common sense and a knowledge of current technic in exhibition projects. Out of the committee's evaluation of their work and its results have come certain conclusions that may serve others who are interested in suggesting graphically to laymen the things that they should know about the teeth in relation to the health of the body as a whole.

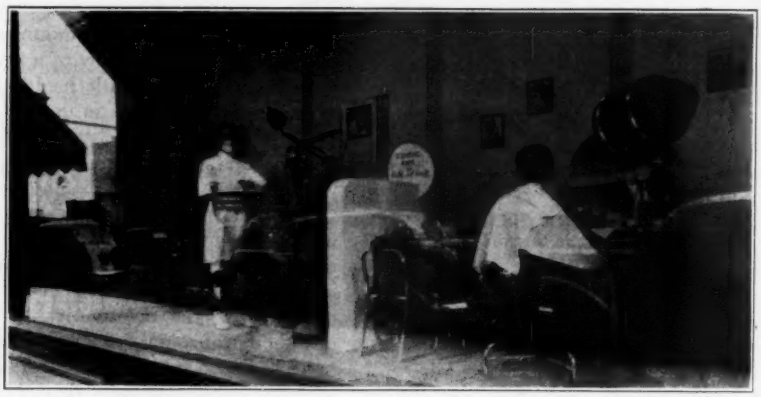


Fig. 1.—Window display, educational exhibit of the Pennsylvania Dental Society, 1937.

Any professional health group should be as much concerned with prevention as with cure. Prevention, however, is intimately connected with educational procedures, and the presence of professional teachers among us has too often led us to forget the very real need for functional education. We are inclined to be content with the assumption that the schools will do the work and forget that the very best learning takes place in the midst of going processes and not as it is temporarily spotlighted in an institution of learning. Correct attitudes and interests grow with dynamic knowledge.

The practicing physician and dentist need not, of necessity, be good teachers even in their own field. It may well be that the directors of many of our school systems, lacking knowledge of the possibilities, have been content with superficial medical diagnosis, advice and treatment. But school physicians, dentists and nurses of the future must be teachers of prevention as well as practitioners of cure. This will call for people who are not only skilled in diagnostics, but who also have either developed a desire to arouse an interest in preventive measures or have perhaps received some training in pedagogic methods. Nor should the efforts to teach

prevention be limited to the efforts of school doctors. Each has a responsibility to give to his private office patients an understanding of what he is doing for them so that they may better know how to meet future dental difficulties either in themselves or in their children.

Furthermore, it seems to us that, since the educational officers of their school systems cannot be expected to fully understand the possibilities for health improvement under sound teaching, the medical and dental professions should feel a definite responsibility for a vigorous functioning of the health departments in our school systems, no less in examinations and care than in the teaching of prevention. The educational programs of the school physicians and dentists should be as much subject to supervision and criticism as are class room practices of the teachers of the regular academic subjects.

Obviously, this means that we are concerned with more than repair. Everything that we do must help to maintain the normal function of the whole. To accomplish this involves more than treatment. The patient's attitude toward prevention as well as treatment must be properly developed. This is the work of the health educator.

With these generalizations in mind, the committee studied the possibilities for an exhibition that might suggest to the school dentist ways of illustrating dental problems for students, as well as introducing the public to the modern foundations and concepts of dental hygiene.

Two ways of handling such an exhibition were possible: First, a single story could be told with each booth dealing with but one phase of the whole. To arrange for the details of such a display required more time than we had at our disposal. This made it necessary to follow a second plan, which perhaps is just as satisfactory as the first. Under this plan, each display was complete in itself and its purpose was to reflect and further a consistent point of view.

Fig. 2.—Window display, educational exhibit of the Pennsylvania State Dental Society, 1937.

Several observations on the effectiveness of this first exhibit may aid those who plan future displays.

Decide first what you wish to demonstrate and then plan to limit the number of objects to the bare minimum that will make clear the point that you wish to emphasize. The eye can absorb only so much in passing and few will stop to study the exhibit intensively. Note the art used in trimming the windows in a first-class jewelry store. The window

dresser does not distract attention from one central and beautiful bit of jewelry by surrounding it with a mass of trash. The same principle applies in presenting ideas. Show one at a time.

Correlated with the foregoing are these further suggestions:

1. Have little printed descriptive materials. Where it is absolutely necessary have the letters at least one-half inch high.

2. Photographs and charts must be large, clear and few in number. The large number of small photographs may suggest the industry of the exhibitor, but not his teaching sense. Few will stop to look at small pictures.

7. A small pamphlet summarizing in short pointed sentences the main points of the exhibit may serve to recall at a later date some of the features that you desire to fix in the visitor's mind.

As the program indicates, part of the exhibit included a radio forum and a public meeting. Special invitations were sent to parent-teacher associations, and general invitations to the exhibition and public meeting appeared in the local newspapers.

The committee believes that education by exhibit, if the foregoing rules are followed, is a definite contribution to instruction in health education. Many variations of such exhibitions can be planned and set up by school children, who will learn much by the process, and the American Dental Association might well have its general education committee suggest an ever-changing series of subjects to be developed by local groups for county, state or national meetings.

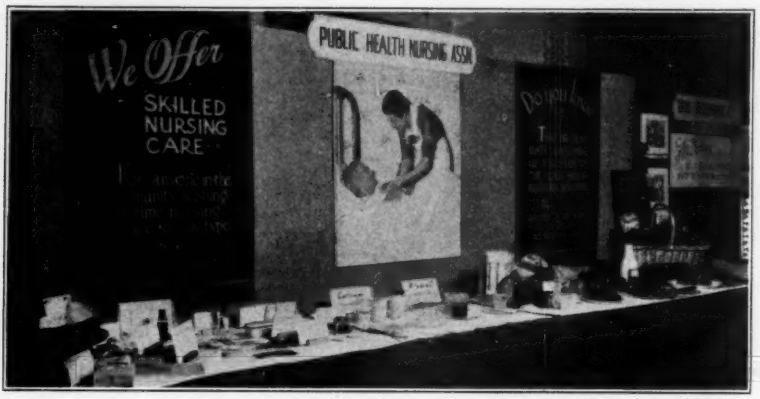


Fig. 3.—Indiana State Board of Health exhibit at the Pennsylvania State Dental Society 1937 meeting.

3. Most technical details can be made simple and intelligible if enough thought is spent on them.

4. Do not use more than one or two microscopes in any one exhibit. Everyone wants to look through each microscope and this delays the progress of the visitors.

5. Have live animals or moving objects in the exhibit whenever possible.

6. Never invite an organization to send in material unless you have seen it before or can tell the contributor exactly what you want.

Although an exhibit should be a graphic summation of knowledge in a given field that can be grasped at a glance, it should not be an end in itself. Its success must be measured by its ability to promote thought and action on the part of the observers.

DENTAL ECONOMICS

DENTAL SURVEY*

By R. P. Thomas, D.D.S., Louisville, Ky.

The problem of formulating a reliable survey of the number of dentists in the United States or in any particular region is in the very nature of things a most difficult matter. The accompanying survey is presented with a full realization of that fact, and to those who are most intimately concerned, the plea is hereby made that it be studied carefully to the end that the nearest approach to accuracy may be achieved. The committee who compiled this survey are entitled to great consideration for undertaking a formidable task.

This survey was prompted by the vital need for such statistics. Numerous figures have been quoted from time to time, but it has not been possible to verify the quotations. It was believed that the most accurate place from whence the figures could be obtained was the legal records of the boards of examiners.

It has often been stated that there are more deaths and retirements each year than graduations. Such was not the experience of the local board of examiners, and the results of this survey show that it has not been the experience of the other boards.

The states were divided into five groups for comparison and analysis. In Group 1, the states having more than 3,000 dentists, were California, Illinois, Massachusetts, New York, Ohio and Pennsylvania. In Group 2, those having from 2,000 to 3,000 dentists, were Indiana, Michigan, Minnesota, Missouri, New Jersey, Texas and Wisconsin. In Group 3, those from 1,000 to 2,000, were Iowa, Kansas, Connecticut, Nebraska and Washington. In Group 4, those from 500 to 1,000, were Colorado, the District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, North Carolina, Oklahoma, Tennessee, Virginia, West Virginia, Alabama and Oregon. In Group 5, those having less than 500, were Delaware, Idaho, Maine, Montana, Nevada, North Dakota, South Carolina, South Dakota, Utah, Vermont, Wyoming, Arizona, Mississippi, Rhode Island, Arkansas and New Hampshire.

All states reported the number of dentists with the exception of Illinois, which reported that there had been 15,000 licenses issued since the creation of their board of examiners. All the figures on Illinois were reported with the exception of the loss in licenses since the board was created, licenses in force April 1, 1936, and dentists practicing within the state. Those three items were estimated and were arrived at in the following manner:

The figures of the other states in Group 1 were compiled and from them the loss in the number of licenses per year since the board began the issuance of licenses was determined. The average of the other states was taken as the figure for Illinois. As the Illinois board had been issuing licenses since 1881, or fifty-five years, the total lost per year was multiplied by 55, which gave the loss of licenses for Illinois as 3,360. The same method was used in

*Conducted under the auspices of the National Association of Dental Examiners by the secretary.

TABLE 1.—DATA ON LICENSES

	Board Created Year	Licenses Issued Since Board Created	Loss in Licenses Since Board Created	Licenses in Force April 1, 1936
Alabama		1,444	702	742
Arizona		283	118	165
Arkansas	1887	1,112	805	407
California	1885	8,528	2,398	6,130
Colorado	1900	1,777	856	921
Connecticut	1893	1,506	256	1,250
Delaware	1885	342	223	119
Dist. of Columbia	1892	1,469	749	720
Florida	1889	1,356	573	783
Georgia	1879	1,710	781	929
Idaho	1899	710	359	351
Illinois	1881	15,000	3,360	11,640
Indiana	1887	4,094	1,761	2,333
Iowa	1882	3,749	1,777	1,972
Kansas	1885	2,981	1,312	1,266
Kentucky	1878	2,135	1,073	1,062
Louisiana	1880	1,500	705	895
Maine	1891	760	256	504
Maryland	1884	2,069	1,159	910
Massachusetts	1887	6,599	3,127	3,472
Michigan	1907	4,626	1,126	3,500
Minnesota	1885	3,633	1,005	2,628
Mississippi	1890	625	285	340
Missouri	1905	7,357	3,821	3,536
Montana	1895	600	200	400
Nebraska	1905	2,348	1,274	1,074
Nevada				71
New Jersey	1890	3,834	825	3,009
New Hampshire	1891	600	147	473
New Mexico				
New York	1895	12,369	1,829	10,540
North Carolina	1879	1,421	467	954
North Dakota	1885	1,063	678	385
Ohio	1892	8,064	3,614	4,450
Oklahoma	1891	2,037	1,017	1,020
Oregon	1887	1,932	762	1,170
Pennsylvania	1897	9,560	2544	7,016
Rhode Island	1899	901	478	423
South Carolina	1875	506	80	442
South Dakota	1885	834	385	449
Tennessee	1891	2,384	1,333	1,051
Texas	1907			2,094
Utah	1894	803	353	450
Vermont	1883	299	105	194
Virginia	1886	1,443	507	936
West Virginia	1898	1,100	190	910
Washington				1,558
Wisconsin	1885	3,800	951	2,849
Wyoming	1905	283	117	166
		131,546	46,443	88,659
Province of Ontario, Canada	1868	3,578	1,678	1,900

TABLE 2.—STATISTICS ON DENTISTS IN PRACTICE

	In Practice as Reported by Board	In Practice as Reported by State Secretary	Listed in Polk's Directory 1928	Licensed but in Practice in Another State
Alabama	653	653	616	89
Arizona	134		127	31
Arkansas	335		444	72
California	5,799	5,799	4,679	331
Colorado	763		752	158
Connecticut	1,121		848	129
Delaware	109	100	92	10
Dist. of Columbia	630	589	539	87
Florida	688	600	740	95
Georgia	800	800	871	129
Idaho	246	252	282	105
Illinois	11,370		5,557	270
Indiana	2,008	1,972	1,992	325
Iowa	1,825	1,825	1,717	147
Kansas	1,128	1,266	1,065	138
Kentucky	862	862	816	170
Louisiana	810	840	842	110
Maine	422	422	450	82
Maryland	800		802	110
Massachusetts	3,250	3,350	3,452	222
Michigan	3,000		2,540	500
Minnesota	2,184	2,176	1,972	444
Mississippi	274	375	333	66
Missouri	2,422	2,422	2,419	1,114
Montana	300	303	315	100
Nebraska	1,034	1,014	996	40
Nevada	69		56	2
New Jersey	2,614	2,800	2,213	395
New Hampshire	251		262	222
New Mexico			100	
New York	10,340		7,329	200
North Carolina	809	770	864	145
North Dakota	300	300	297	85
Ohio	4,200		3,538	250
Oklahoma	822		812	198
Oregon	905	875	914	265
Pennsylvania	6,909	6,477	5,644	110
Rhode Island	409		393	14
South Carolina	426	426	455	16
South Dakota	331		347	118
Tennessee	957		867	94
Texas	2,041	2,182	1,694	53
Utah	370	326	339	80
Vermont	155		172	39
Virginia	812		768	124
West Virginia	810	810	687	100
Washington	1,423		1,295	135
Wisconsin	2,455	2,442	2,355	394
Wyoming	120	120	122	56
	80,495	43,148	66,781	8,159
Province of Ontario, Canada	1,900			

determining the number of licenses held by dentists in Illinois, but in practice in some other state. This was 270. Then the two figures were added and this total subtracted from the 15,000. It showed Illinois to have 11,370 dentists in actual practice in that state. In 1933, a committee of the National Association of Dental Examiners made a survey, and at that time they estimated the number of licenses held in Illinois as 12,500. It is not known how that number was determined.

Lest the fact that this survey sometimes shows a loss in licenses per year and an increase in the number of graduates per year be confusing, the following explanation is offered: In the beginning, in some instances, certain states license the entire number of dentists within the state during a period of two or three years. This naturally involved not the young men only, but men of all ages. Eventually, there were a greater number of older men in practice than young men, and consequently, many men who died were not replaced. At what years that occurred cannot be determined. However, the survey shows that, since 1931, there has been a slight increase in graduates over the number of those dead and those retired from practice.

TABLE 3.—YEARLY AVERAGE* DEATHS AND RETIREMENTS

	Deaths and Retirements	Per Thousand		Deaths and Retirements	Per Thousand
Alabama	7.8	11.9	Nevada	0.4	5.8
Arizona	2.7	20.1	New Jersey	26.4	10.0
Arkansas	2.8	8.4	New Hampshire	5.0	19.9
California	109.2	18.9	New Mexico		
Colorado	8.0	11.0	New York	200.0	19.3
Connecticut	28.0	24.0	North Carolina	10.6	13.1
Delaware	2.6	23.8	North Dakota	5.2	17.3
Dist. of Columbia	9.0	14.4	Ohio	64.0	15.0
Florida	10.9	15.8	Oklahoma	32.0	38.0
Georgia	14.7	18.4	Oregon	26.2	28.9
Idaho	13.0	52.4	Pennsylvania	118.1	17.1
Illinois	201.0	17.1	Rhode Island	9.0	22.0
Indiana	32.2	15.5	South Carolina	6.6	17.1
Iowa	45.6	25.0	South Dakota	5.2	15.7
Kansas	38.2	24.8	Tennessee	15.2	15.9
Kentucky	43.4	50.0	Texas	34.9	17.1
Louisiana	11.7	14.6	Utah	10.0	37.0
Maine	8.2	19.4	Vermont	1.7	10.6
Maryland	11.7	14.6	Virginia	17.2	21.0
Massachusetts	42.8	13.1	West Virginia	10.6	13.2
Michigan	36.6	12.2	Washington	35.3	24.9
Minnesota	34.2	15.0	Wisconsin	39.0	15.0
Mississippi	4.0	14.6	Wyoming	2.8	23.3
Missouri	51.5	21.3		1,519.0	20.0
Montana	2.0	6.0	Province of Ontario, Canada	37.0	19.5
Nebraska	66.0	63.0			

*For past five years.

TABLE 4.—STATISTICS ON CANDIDATES FOR LICENSE*

	Number Taking Examination	Recent Graduates Taking Examination	Dentists out of School One Year or Longer Taking Examination	Recent Graduates Passing Examination	Dentists out of School One Year or Longer Passing Examination	Failures in License Examination Per Cent
Alabama	18.0	15.2	2.8	14.4	2.3	9.2
Arizona	11.2	5.4	5.8	2.5	2.7	53.5
Arkansas	13.8	10.4	3.4	8.4	1.2	30.6
California	148.5	115.5	33.0	92.4	26.4	20.0
Colorado	13.2	9.4	3.8	8.4	3.2	10.7
Connecticut	68.4	49.4	19.0	35.4	13.0	28.3
Delaware	4.8	3.0	1.8	2.1	1.3	30.3
Dist. of Columbia	25.6					
Florida	38.4	22.0	16.4	12.8	7.7	46.9
Georgia	40.4	36.0	4.4	35.8	4.4	0.6
Idaho	8.2	5.2	3.0	3.8	2.0	31.0
Illinois	200.0	170.0	30.0	139.4	24.6	18.0
Indiana	47.6	42.9	4.7	40.8	4.5	4.9
Iowa	46.4	39.3	7.1	38.9	7.0	9.9
Kansas						
Kentucky	31.2	29.4	1.8	26.1	1.6	11.6
Louisiana	31.0	29.3	1.7	28.8	1.7	1.8
Maine	9.8	6.4	3.4	5.9	3.1	7.5
Maryland	41.2					
Massachusetts	63.4	49.1	14.3	46.1	13.4	9.4
Michigan	131.4	108.0	23.4	79.7	17.3	26.2
Minnesota	63.4	57.0	6.4	49.9	5.6	12.5
Mississippi	10.6	10.0	0.6	9.0	0.6	9.4
Missouri						
Montana	10.0	8.8	1.2	7.0	1.0	8.0
Nebraska	36.6	34.3	2.3	34.3	2.1	0.6
Nevada	3.5	1.3	2.2	0.3	0.6	76.2
New Jersey	242.0	114.4	127.6	71.4	66.4	43.8
New Hampshire	11.0	4.2	6.8	4.1	6.7	1.8
New Mexico						
New York	444.0	420.0	24.0	330.4	19.4	18.4
North Carolina	28.0	23.0	5.0	18.8	2.8	22.2
North Dakota	11.8	8.4	3.4	7.1	2.9	15.3
Ohio	140.0	118.8	21.2	101.2	17.6	14.8
Oklahoma	21.2	15.3	5.9	13.4	5.2	12.0
Oregon	28.2	24.2	4.0	20.7	3.3	16.3
Pennsylvania	260.8	258.0	3.0	251.8	3.0	2.3
Rhode Island	19.0					
South Carolina	9.2					
South Dakota	6.6	5.3	1.5	3.5	0.8	35.0
Tennessee	36.0	29.6	6.4	29.6	6.1	0.4
Texas	77.8	57.5	20.3	44.0	15.5	23.4
Utah	13.0	12.1	0.9	10.8	0.8	11.0
Vermont	4.2	3.6	0.6	3.6	0.6	
Virginia	33.4	26.8	6.6	25.5	6.3	4.7
West Virginia	18.2	15.9	2.3	13.7	2.0	13.4
Washington						
Wisconsin	61.2	53.8	7.4	50.4	6.9	6.0
Wyoming	5.0	3.0	2.0	2.4	1.6	21.5
	2,587.0	2,051.0	446.0	1,725.0	315.2	18.45
Province of Ontario, Canada	38.0					

*Yearly average for past five years.

TABLE 5.—STATISTICS ON MEMBERSHIP*

	Reported by A. D. A. Secretary	Percentage of Members in A. D. A. Reported by State Secretary	Percentage of Members in A. D. A. Reported by Boards
Alabama	340	52	52
Arizona	77		58
Arkansas	166		50
California	2,847	49	49
Colorado	494		65
Connecticut	743		66
Delaware	53	53	49
Dist. of Columbia	358	64	57
Florida	389	53	56
Georgia	413	52	52
Idaho	75	30	31
Illinois	3,318		
Indiana	991	50	49
Iowa	1,057	59	59
Kansas	479	38	43
Kentucky	452	52	52
Louisiana	423	50	52
Maine	195	46	46
Maryland	326		41
Massachusetts	1,402	42	43
Michigan	1,443		41
Minnesota	1,472	67	67
Mississippi	210	56	76
Missouri	1,071	44	44
Montana	158	52	52
Nebraska	518	50	50
Nevada	27		40
New Jersey	1,641	58	63
New Hampshire	130		52
New Mexico	67		
New York	4,129		40
North Carolina	439	57	50
North Dakota	189	63	63
Ohio	2,119		50
Oklahoma	416		51
Oregon	367	42	41
Pennsylvania	3,137	48	45
Rhode Island	167		41
South Carolina	154	36	36
South Dakota	177	50	54
Tennessee	597		62
Texas	965	44	47
Utah	238	72	64
Vermont	86		56
Virginia	418		51
West Virginia	330	40	40
Washington	650		47
Wisconsin	1,265	51	50
Wyoming	67	56	56
	37,245	51.6	50.5

*Reported as of December 31, 1935.

TABLE 6.—STATISTICS ON NUMBER OF GRADUATES* AND POPULATION†

	Reported by Deans	Population	Population per Dentist
Alabama	None	2,834,000	4,340
Arizona	None	386,000	2,880
Arkansas	None	1,999,000	5,967
California	139	5,639,000	972
Cólorado	None	1,062,000	1,392
Connecticut	None	1,717,000	1,531
Delaware	None	256,000	1,431
Dist. of Columbia	58	594,000	943
Florida	None	1,614,000	2,346
Georgia	70	3,345,000	4,181
Idaho	None	479,000	1,947
Illinois	233	7,817,000	688
Indiana	38	3,429,000	1,707
Iowa	36	2,534,000	1,389
Kansas	None	1,848,000	1,207
Kentucky	40	2,846,000	3,301
Louisiana	32	2,120,000	2,617
Maine	None	845,000	2,002
Maryland	75	1,669,000	2,086
Massachusetts	86	4,375,000	1,346
Michigan	108	4,661,000	1,553
Minnesota	72	2,627,000	1,203
Mississippi	None	1,961,000	7,157
Missouri	142	3,913,000	1,615
Montana	None	513,000	1,770
Nebraska	43	1,364,000	1,319
Nevada	None	99,000	1,435
New Jersey	None	4,288,000	1,640
New Hampshire	None	502,000	
New Mexico	None	402,000	
New York	207	12,889,000	1,247
North Carolina	None	3,417,000	4,223
North Dakota	None	700,000	2,333
Ohio	31	6,707,000	1,596
Oklahoma	None	2,509,000	3,052
Oregon	51	1,008,000	
Pennsylvania	285	10,066,000	1,457
Rhode Island	None	681,000	1,690
South Carolina	None	2,012,000	4,723
South Dakota	None	675,000	2,040
Tennessee	42	2,904,000	3,034
Texas	37	6,077,000	2,977
Utah	None	515,000	1,397
Vermont	None	377,000	2,432
Virginia	26	2,637,000	3,247
West Virginia	None	1,816,000	2,168
Washington	None	1,633,000	1,147
Wisconsin	55	2,908,000	1,184
Wyoming	None	232,000	1,933
	1,956	127,501,000	103,845

*Yearly average for past five years.

†Estimate of Bureau of Census, July 1, 1935.

TABLE 7.—STATISTICS ON HYGIENISTS

	Hygienist Board Created Year	Hygienists' Licenses Issued Since Board Created	Hygienists' Licenses in Force*
Alabama[1]	1919	60	30
Arizona	None		
Arkansas	1921	5	3
California	1922	157	136
Colorado	1919	58	
Connecticut	1918	420	395
Delaware	1929	25	15
Dist. of Columbia	1924	118	
Florida	1926	84	52
Georgia	1928	126	75
Idaho	None		
Illinois	None		
Indiana	None		
Iowa	1921	50	31
Kansas	1935	29	26
Kentucky	None		
Louisiana	1928	7	7
Maine	1918	58	21
Maryland	None		
Massachusetts	1917	837	322
Michigan	1919	257	220
Minnesota	1919	413	287
Mississippi	1922	16	16
Missouri	None		
Montana	1935	50	50
Nebraska	None		
Nevada	None		
New Jersey	None		
New Hampshire			
New Mexico			
New York	1916	2,128	
North Carolina	None		
North Dakota	None		
Ohio	1925	162	116
Oklahoma	1920	21	8
Oregon			
Pennsylvania	1921	613	376
Rhode Island	1931	30	12
South Carolina	1922	21	21
South Dakota	None		
Tennessee	1920	65	45
Texas	None		
Utah	None		
Vermont	1921	16	16
Virginia	None		
West Virginia	1915	35	30
Washington			63
Wisconsin	1921	375	228
Wyoming	1921	2	2
		6,238	2,603

*April 1, 1936.

COUNCIL ON DENTAL THERAPEUTICS

ACCEPTED DENTAL REMEDIES

The following articles have been accepted as conforming to the rules of the Council on Dental Therapeutics of the American Dental Association. The Council wishes dentists to understand that the admission of an article does not imply a recommendation. A copy of the rules that govern the Council in the consideration of articles will be sent on request.

COUNCIL ON DENTAL THERAPEUTICS.

DENTIFRICES*

Graver's Tooth Powder: Composition: Each 100 gm. is said to contain calcium carbonate (Sturge "100"), 80 gm.; sodium bicarbonate, U.S.P., 12.5 gm.; saccharin (soluble), U.S.P., 0.5 gm.; methyl salicylate, U.S.P. 1 gm.; oil of peppermint, U.S.P., 1 gm.; olive oil castile soap, U.S.P., 5 gm.

ABRASIVENESS: 2.4 mg. per 1,000 revolutions (John & E. Sturge instrument).

Manufactured by Strong-Cobb Chemical Company, Cleveland, Ohio. Distributed by C. J. Graver & Company, Cleveland, Ohio. No U. S. patents or trademarks.

Hughes Dental Cream: Composition: Each 100 gm. is said to contain dicalcium phosphate (Victor), 58.0 gm.; glycerin, 17.61 gm.; water, 21.60 gm.; alcohol, 0.86 gm.; gum tragacanth, 0.86 gm.; saccharin, 0.07 gm.; flavoring oils (oil of peppermint, oil of spearmint, oil of limes, oil of lemon, oil of pini pumilionis, oil of fennel, oil of sweet birch, oil of cloves, menthol, U.S.P., recrystallized), 1.00 gm.

ABRASIVENESS: 0.2 mg. on antimony block under a weight of 100 gm. in 4,000 revolutions (Victor apparatus, A.D.R. 1937, page 91).

Manufactured by Lactona, Incorporated, St. Paul, Minnesota. No U. S. patent or trademark.

*A.D.R. 1937, p. 105.

NAMING OF DENTIFRICES

THE following statement regarding the naming of new dentifrices submitted to the Council for acceptance is presented for the information of dentists and manufacturers.

The present position of the Council on the naming of dentifrices provides that the names which were on the market before the formation of the Council are acceptable provided advertising is not written in such a way as to lay emphasis on any virtue connected with the name; but that new dentifrices should be designated "So-and-So's Tooth Paste," "So-and-So's Tooth Powder," or "Dentifrice." The title "Dr." or "D.D.S." is in no sense acceptable.

Accepted Dental Remedies, 1937, page 18 states:

For dentifrices put on the market after the formation of the Council, one of the conditions of acceptance is that the product be named "So-and-So's Tooth Paste" or "So-and-So's Tooth Powder" or "Dentifrice." This is intended to minimize the many misleading and tricky trade names for this class

of products. Under no conditions can the Council accept a dentifrice which bears the prefix "Doctor" or the suffix "D.D.S." as part of the principal designation.

This has been revised to read:

For dentifrices put on the market after the formation of the Council, the Council prefers the adoption of such names as "So-and-So's Tooth Paste" or "So-and-So's Tooth Powder" or "Dentifrice." The Council, while promoting the use of such names, will consider for acceptance the names of established lines of cosmetics or drugs, of which a dentifrice may be an item, but the Council will not accept any names which carry misleading connotations as to properties of a single item of the whole line, or which are applied to items which may be in conflict with the rules of the Council. It, however, will encourage in every instance conformity with its original position of naming new dentifrices.

Under no conditions can the Council accept a dentifrice which bears the prefix "Doctor" or the suffix "D.D.S." or dentist as part of the principal designation.

It is this position which will guide the Council in the consideration of names for new dentifrices.

METAPHEN GERMICIDAL SOLUTION

ANNOUNCEMENT of acceptance of Metaphen Germicidal Solution appeared in THE JOURNAL for October 1937, page 1732. The description of the product was given as follows:

Metaphen Germicidal Solution: 1 part Metaphen dissolved in 2,500 parts of water containing sodium hydroxide, U.S.P., 0.81 gm.; sodium carbonate, monohydrated, 12.5 gm.; sodium silicate liquid (40° Be), 30 gm.; ethylene glycol, 500 gm., and benzyl alcohol, 100 gm.

Manufactured by the Abbott Laboratories, North Chicago, Ill.

At the request of the firm, this description is being revised to read as follows:

Metaphen Germicidal Solution: 1 part Metaphen dissolved in 2,500 parts of an aqueous solution containing sodium hydroxide, U.S.P., 0.81 gm., sodium carbonate, monohydrated 12.5 gm., ethylene glycol, 500 gm., and benzyl alcohol, 100 gm.

Manufactured by the Abbott Laboratories, North Chicago, Ill.

The composition of the product now being sold should adhere to the revised composition.

SALVARSAN GLUCOSE SOLUTION

ANNOUNCEMENT of acceptance of Salvarsan Glucose Solution 5% appeared in THE JOURNAL for October 1933, page 1902.

The firm has advised the Council that this dosage form is being discontinued and in its place a Salvarsan Glucose Solution 10% is being marketed. This product has the following description:

Salvarsan in Glucose Solution (Winthrop), 3 cc. ampuls. Each ampul contains 3 cc. of a solution of salvarsan in the form of the base, 10 per cent, in a solution of glucose, approximately 40 per cent.

Manufactured by Winthrop Chemical Co., Inc., New York.

The composition of the product now being sold should adhere to the revised composition.

CURRENT LITERATURE

Roentgen Treatment of Infection from Human Bites

By R. Manges Smith and Willis F. Manges

In addition to a review of the literature, the authors give the roentgen treatment used for infections, principally of the hand, from human bites. They describe also nine of their cases, giving the cause of the lesion, course of the resulting infection and treatment applied. Of the nine cases treated one was that of a dentist whose hand had been bitten while he was working on a patient; and seven bites were the result of blows against the teeth with the hand. One case, that of a lip infection in a child from a self-inflicted bite, is of interest when compared with injuries of the lip that sometimes follow block anesthesia of the lower jaw, particularly in children. The authors believe that roentgen treatment of lesions from human bites causes a material shortening of the course of these infections, which otherwise are of very long duration.—*Am. J. Roentgenol & Rad. Therap.*, 38:720, November 1937.

Grant Van Huysen.

Lipstick Dermatitis: With a Report of a Case Due to Eosin

By F. F. Hellier

The use of lipstick is known to result in a dermatitis at times. The fact that the patient may be able to effect a cure without medical aid may account for the relative scarcity of reported cases. The typical clinical picture is one of itching or even pain of the lips after about two to twenty-four hours, an appearance of swelling or puffiness and, in some instances, the formation of vesicles on the lips. If no further lipstick is applied, the condition usually clears up in less than ten days. In certain cases, the erythema and itching may spread to the eye or, as in one report, to the tip of the tongue. The attack may follow the application of lipstick which has been used over a long period of time, but to which the user has just become sensitive. Lipsticks consist chiefly of a base (waxes, alcohols, oils and fatty acids), perfume and coloring matter. The individual may be sensitive to the base or perfume, but is more frequently sensitive to the coloring matter. The author believes eosin to be the harmful dye in most instances and cites case histories in which this was found true. Exposure to sunlight may be another factor, a photosensitiveness being increased by the lipstick. Patch tests may be used to determine the causative factor.—*Brit. J. Derm. & Syph.*, 49:485, November 1937.

Hamilton Robinson.

Antiseptics and Wound Healing

By W. W. Sager, E. B. Vedder and C. Rosenberg

A method was devised to test the toxicity of various antiseptics as regards bacteria and the cells of living animals. Two incisions were made bilaterally in the abdominal wall of an animal and were infected with equal quantities of a culture of virulent *Staphylococcus aureus*. One wound was left untreated as a control. In the other an antiseptic was placed for a period of from twenty to twenty-five minutes. Tincture of metaphen, tincture of merthiolate, a 2 per cent aqueous solution of gentian violet and azochloramid were tested. It is concluded that the antiseptics used were unable to improve the wounds owing to the injury of the animal cells by the antiseptic. Since antiseptics are necessary, further study of their effects both on bacteria and on living cells in the animal are suggested.—*Am. J. Surg.*, 38:348, September 1937.

Hamilton Robinson.

Foundations for .. Dental Library

By J. W. Hunt

In an effort to establish a library at the Walter G. Zoller Memorial Dental Clinic, the author first surveyed the scope of its work. Since this clinic is to carry on research in dental problems and train teachers and specialists, as well as to serve indigent patients, emphasis is placed on literature for research use. Dental reference works were secured and texts in the related sciences of biochemistry, physiology, bacteriology and

medicine and dental periodicals. The periodicals included are: JOURNAL OF THE AMERICAN DENTAL ASSOCIATION, *Angle Orthodontist, Archives of Clinical and Oral Pathology, British Dental Journal, Canadian Dental Research Foundation Bulletin, Deutsche Zahn-, Mund- und Kieferheilkunde, Dominion Dental Journal, International Journal of Orthodontia, Journal of Dental Research, Journal of Periodontology, Revue de Stomatologie, Schweizerische Monatsschrift für Zahnheilkunde, Zahnärtliche Rundschau, Zeitschrift für Stomatologie* and *Zentrablatt für Gesamte Zahn-, Mund- und Kieferheilkunde.* The librarian believes that this particular library "will give better service by increasing its reference and periodical resources than by purchasing textbooks which are out of date even as they leave the press."—*Bull. Med. Lib. A.*, 26:81, October 1937.

HAMILTON ROBINSON.

Periodicals Useful in the Dental Library

By INGO HACKH

BY comparing the frequency of quotation of dental periodicals in dental articles, some indication of the usefulness of various journals can be computed. Dividing the number of quotations by the number of volumes issued, the English language dental periodicals are listed as follows: JOURNAL OF THE AMERICAN DENTAL ASSOCIATION, 168 quotations per volume; *Dental Cosmos* 61.8; *Journal of Dental Research*, 53; *International Journal of Orthodontia*, 26.4; *British Dental Journal*, 21.4; *Oral Hygiene*, 16.3; *Dental Items of Interest*, 12.8; *Dental Digest*, 5.9; *Dental Summary*, 5.5; *Pacific Dental Gazette*, 4.5; *Dental Outlook*, 4.5 and *Dental Record*, 3.2. Foreign language dental periodicals and medical and scientific journals are also listed. The author notes "a healthy and steady increase in the use of bibliographic sources by dentists."—*Bull. Med. Lib. A.*, 25:109, September 1936.

HAMILTON ROBINSON.

Sodium Content of Bone and Other Calcified Material

By HAROLD E. HARRISON

A SAMPLE of human enamel was washed with distilled water, digested on the steam bath for twenty-four hours in 5 per cent potassium hydroxide in 80 per cent alcohol and washed free of alkali. Analytic data are as follows (millimols per hundred grams residue): calcium, 928; phosphorus, 564; chlorine, 8.4; sodium, 29.9; calcium to sodium ratio, 31.1 to 1. The calcium:sodium ratio is the same as that found for bone and in two pathologic calcifications. The "insoluble" sodium is perhaps in the apatite lattice.—*J. Biol. Chem.*, 120:457, 1937.

H. C. HODGE.

Is Pulp Testing with Carbon Dioxide Snow Harmful?

IF applied, as the author recommends, with a curved-tip bakelite syringe for only a few seconds, it is not harmful to the tooth. This is sufficient time to insure positive results in all vital teeth; whereas a five-minute application could be used, if necessary, without cracking the enamel, or injuring the pulp as shown by histologic examination. Advantages of the method are simplicity, surety and harmlessness. It should not touch the soft tissues.—*Ztschr. f. Stomatol.*, 16:1096, August 27, 1937.

MARTIN DEAKINS.

Association of Scurvy with Oral Diseases

By FRANK C. CADY

OUTBREAKS and epidemics of scurvy are preventable in the light of a better understanding of the disease and methods of preservation of the element (cevitamic acid) concerned in its prevention. Factors in its preservation are instability in the presence of heat; drying, and oxidation. Scarcity of foods containing vitamin C and climatic conditions where the summer is short make it probable that many districts do not obtain sufficient vitamin C for good health. This is particularly likely to occur among the poor, and there is a close association between subclinical scurvy and gingivitis and Vincent's infection. This contention is supported by group studies and surveys of sections of the population whose diet is low in antiscorbutic foods. A careful study of dietary deficiency as it relates to this disease might reveal new factors in its etiology.—*Pub. Health Rep.*, 52:1526, October 29, 1937.

VIRGIL D. CHEYNE.

Clinical Importance of Root Granuloma

By J. SZARBO

HARMFUL effects of granuloma can be systemic or localized. The etiology of these

conditions may be demonstrated, first, by sedimentation of the blood cells. In chronic infection, dispersion of serum proteins, serum albumin, serum globulin and fibrinogen undergoes a change. The positive electric charge of these particles is augmented. The negative charge of the red cells becomes neutralized so that they do not repulse each other. To be effective, this test must be given before and after elimination of foci. Secondly, the blood picture can be examined in the same way, before and after removal of the focus. White blood cells should decrease after the focus is eliminated. Thirdly, if all other acute infections can be excluded, a culture of the same bacteria from the primary focus which are circulating in the blood and production of the same condition in another animal afford a specific diagnosis. Other aids in this respect are investigation of metabolic disturbances and intracutaneous injections of vaccines.—*D. Rec.*, 51:593, November 1937.

L. H. Garrison.

Osteomyelitis of the Superior Maxilla in New-Born Infants

By A. Goldbloom and H. Bacal

Although this condition is relatively rare, it deserves more prominence than has been accorded it in the literature. A strikingly uniform picture is presented: fever, swelling of the cheek and eyelids, suppuration pointing on the cheek or inside the mouth, unilateral nasal discharge, augmented pressure on the cheek and, finally, sequestration of one or all surfaces of the maxilla, with loss of deciduous teeth and permanent tooth buds. Healing then leads to a deformity of the affected side.—*Canad. M. A. J.*, 37:443, November 1937.

E. Hampp.

Rapid Method of Preparing Ground-Tooth Sections

By G. Bevelander

The apparatus consists of two blocks of wood, five inches by three-fourths by three-eighths. Blocks are tapered and slotted at the tapered end to receive the tooth. The two ends are held together by a wing-top clamp. An inclined straight plank serves as a simplified table bench with attachment for a dental lathe. The incline is lapped on both sides to provide a guide for carrying the tooth secured in the tapering blocks. The tooth may be cut in half with one disk; or, if a thin slab is desired, two may be used. The thickness depends on the distance separating the two disks. For the final grinding, a glass wheel mounted on the motor is used. Small blocks of wood covered with wet cotton are used to hold the slab for final grinding and polishing. After grinding, the section is passed through the alcohols, dried and mounted. Sections suitable for microscopic examination can be prepared in from ten to twenty minutes.—*Anat. Rec.*, 69:333, October 1937.

William E. Hahn.

Immediate Treatment of Facial Fractures

By S. Gordon

With the increased spread of traffic accidents, facial fractures with resultant cosmetic and functional affects are becoming more common. In fractures of the maxilla, the alveolar ridge may be managed by interdental wiring, but a bilateral horizontal fracture must be treated differently. In this case, a band of heavy silver wire is fastened to the upper teeth by several ties of fine wires. The occlusion of the jaws is then checked and the band is fixed from two points to a jury-mast extending downward from a plaster headpiece. Fixation should be maintained for from four to six weeks. When the mandible is involved in fracture, the case is usually bilateral; on one side, through the mental foramina; on the other, in the region of the angle. Fixation by interdental ligation involving the bicuspids and central incisors is usually recommended.—*Canad. M. A. J.*, 37:440, November 1937.

E. Hampp.

Fusobacterium Genus

By E. H. Spaulding and L. F. Rettger

On the basis of biochemical and serologic studies, eighty strains of fusiform bacilli were divided into two main groups. The first group was distinguished by its greater production of acid from carbohydrates, its fermentation of maltose and trehalose and an inability to produce indol, hydrogen sulfide or nitrites. Fermentation differences suggest existence of subgroups. Precipitation tests were inconclusive. In a second report, morphologic differences in general conformity within the two groups are discussed and further methods of diffentiation evaluated. Spiral forms were

rarely found on laboratory media. Pathogenicity for mice and rabbits was demonstrated, but was lost after subculture. Exotoxins were not found. Colony form and structure are illustrated in photographs.—*J. Bacteriol.*, 34:544, 565, 1937.

B. G. Bibby.

Infectious Organism in Osteomyelitis. Part I: Bacteriology of Bone Infection

By W. J. MacNeal

The author traces the bacteriologic aspect of osteomyelitis, beginning with a case in 1840 in which the patient was operated on by Lannelongue and at which Pasteur was present. Samples of pus were taken. Cultures were grown and observations made by Pasteur. The results of many early subsequent investigators, such as Rosenback, Becker, Feodor Krause, Rodet and Koch, are mentioned. Confirmatory studies by many later investigators have confirmed Rodet's findings and have established the fact that osteomyelitis is most commonly due to infection with *Staphylococcus aureus.* At present, we may say that the yellow staphylococcus is the organism in more than half the cases of osteomyelitis. An appreciable number of cases are caused by *Staphylococcus albus, Streptococcus hemolyticus,* the pneumococcus, the typhoid and paratyphoid bacilli, the tubercle bacillus and the spirochete of syphilis. Localization of the disease process depends on diminished resistance at particular sites, associated with growth activity at the metaphysis or with trauma at any place. In the absence of trauma, the narrow space is relatively resistant to infection because of the efficiency of its endothelial cells in the phagocytosis and destruction of bacteria.—*Bone & Joint Surg.*, 19:886, October 1937.

J. Frank Hall.

Infectious Organism in Osteomyelitis. Part II: Bacteriophage and Serum Therapy

By W. J. MacNeal

The author mentions briefly some of the general measures for combating infection in contradistinction to the local measures of incision and drainage. The bacteriophage phenomenon is discussed, as observed in the bacterial culture; the technic of preparation of the material for use in animal experimentation and in human disease, and the effect of the bacteriophage agents in animals and their effects when administered intravenously to patients with osteomyelitis. Several cases are described and illustrated to show what can be accomplished by conservative use of biologic and chemotherapeutic agents to assist general resistance to infection of bone. In summarizing his remarks, the author states that the filterable agent of transmissible bacteriolysis causes solution of the respective bacteria in watery culture; whereas, in the circulating blood of living animals, it does not. However, it does exert an opsonic effect, favoring more effective phagocytosis. When properly employed, the lytic agent aids the body defenses in overcoming infection with the staphylococcus, not only in furuncles, carbuncles and septicemia, but also in lesions of staphylococcic osteomyelitis.—*J. Bone & Joint Surg.*, 19:891, October 1937.

J. Frank Hall.

Morphological and Cultural Studies of the Genus Fusiformis

By M. K. Hine and G. P. Berry

Studies were made of 104 strains of fusiform bacteria isolated from the mouth. On the basis of well-defined morphologic and cultural differences, the strains were divided into three "species" which resembled the *Fusiformis nucleatus, Fusiformis polymorphus* and *Fusiformis dentium* of Bergey. Fermentation tests differ within each "species" and suggest the possibility of further subdivision. Photographs illustrate the different structure and colony forms of the three "species."—*J. Bacteriol.*, 34:517, 1937.

B. G. Bibby.

Diagnosis of Lead Disease in Children

By M. Kasahara

The author observed in children, two varieties of lead disease, anemic and meningitic, the former being characterized by anemia, irritability, emaciation and nausea. Attention is directed to the oral cavity, where black deposits were noted on the necks of the teeth. In the meningitic type symptoms were: cerebral pressure in the presence of tremor of the hands, general convulsions, gritting of the teeth and an increase in pressure of the cerebrospinal fluid.—*Klin. Wchnschr.*, 13:1646, 1934; abstr. *Indian J. Pediat.*, 2:338, 1934-1935.

B. J. Frey.

PRACTICE IN PARAGRAPHS

This department is intended for busy readers. It aims to tell a vivid story in a few words. Items should be of a practical character, and free from padding—not more than a paragraph or two. We exact no limit, but two hundred words can tell most of these stories. Send in your ideas; they will be welcome.

Centric Occlusion—Lest we forget: A good centric occlusion overcomes a multitude of sins.—*A. M. Stinson, Stewartstown, Pa.*

Maxillary Sinus Opening—Medicating an aseptic maxillary sinus opening is bad practice and delays healing. Nature is our best friend and healer.—*A. M. Stinson, Stewartstown, Pa.*

Cotton Fibers—Adding a few cotton fibers to zinc oxide-oil of cloves treatment cement will give strength and increase lasting qualities.—*N. H. Wallace, Canton, Miss.*

Improved Office Polishing Agent—Flour of pumice is mixed into a paste with glycerine to make a very inexpensive dentifrice for the office. A few drops of some essential oil adds much to the quality of such a mixture. (I have found that more patients prefer oil of peppermint.) The pumice and glycerine of such a mixture will separate during the night if a large quantity is prepared, and must be mixed again before using from a dappen dish. To prevent this, a small sample tube of some tooth paste may be added to each 3 ounces during the preparation. The tooth paste will also improve the color of the paste, but I add a few drops of red cake coloring to get a pink paste, which is much more pleasing than the dark colored pumice. It is preferable to make two such mixtures. The first should contain a very fine grade of pumice to be used during prophylaxis; the other, coarse pumice for polishing amalgam fillings.—*J. E. Martin, Roanoke, Va.*

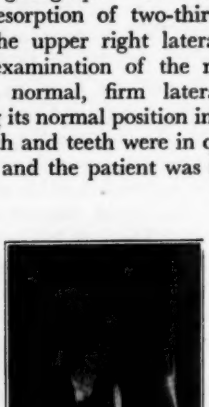
Amalgam—The use of amalgam, imported from France by quack itinerant dentists, in the arts led up to the famous amalgam controversy, resulting in the disruption of the Amercian Dental Convention in 1875. During the fifty-nine years following, through research and investigation, this material has become an indispensable factor in present-day filling requirements. The adherence to certain recognized fundamentals in the hands of many dentists serves as a medium for the accomplishment of works of art, beauty and durability, but unfortunately, in the hands of the majority, the material has been subject to shameful abuse. Incommensurability in fees has been the outstanding cause of inferiority in amalgam restorations, together with the patient's "hit and run" dental chair attitude. The hurried age in which we live tempts the modern dentist to speed his amalgam efforts downward to a fee rather than upward to an ideal. No shrinkage nor expansion occurs in copper amalgam and when it is used as a lining and is covered with a commercial scientifically balanced amalgam, a most desirable combination is formed. If this were explained to patients, they might be more favorable to an increase in fee for something having increased lasting qualities. Discoloring will be less apparent where complete covering is made, but judgment must guide its placing. It is less difficult to get a reasonable fee for the inlay or gold foil filling which has an intrinsic value that, of course, is all out of proportion to the increase of fees.—*Herbert Ely Williams, Red Bank, N. J.*

INCIDENTS OF PRACTICE

A Case of Root Resorption

By Julius F. Miller, D.D.S., New York City.

A man, aged 26, came in for a routine roentgenographic check-up, which showed resorption of two-thirds of the root of the upper right lateral incisor. Clinical examination of the mouth revealed a normal, firm lateral incisor occupying its normal position in the arch. The mouth and teeth were in quite good condition and the patient was in normal health.



Five years previously, on the first roentgenographic examination, another dentist had told the patient that the apex of the tooth was slightly resorbed. Two years later, on examination by another dentist, the patient was advised that the middle third of the tooth had been resorbed.

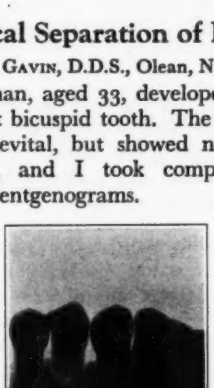
The accompanying illustration shows the condition at present, and as the patient insists that he has never had any injury to that particular area, I am at a loss as to its etiology. Any opinion as to treatment or prognosis would be welcome.

853 Broadway.

Apical Separation of Root

By J. R. Gavin, D.D.S., Olean, N. Y.

A woman, aged 33, developed a loose lower left bicuspid tooth. The tooth appeared devital, but showed no sign of pyorrhea, and I took complete full-mouth roentgenograms.



Upon seeing the apical end of the bicuspid separated from the rest of the root, as shown in the accompanying illustration, I questioned the patient, but she gave absolutely no history except that the root canal had been filled about eight years before.

I extracted the crown of the tooth and had to drill through quite a layer of dense bone to get the root tip out.

109 West State Street.

ANNOUNCEMENTS

ANNOUNCEMENTS must be received by the fifth day of the month in order to be published in the forthcoming issue of THE JOURNAL.

CALENDAR OF MEETINGS

American Dental Association, St. Louis, Mo., October 24-28.

American Academy of Restorative Dentistry, St. Louis, Mo., October 22-23.

American Society for the Advancement of General Anesthesia in Dentistry, New York City, fourth Monday in March and October.

Academy of Anesthesiology in Oral Surgery, New York City, January 19.

Chicago Dental Society Midwinter Meeting, February 14-18.

Five State Postgraduate Clinic, Washington, D. C., March 6-9.

Thomas P. Hinman Midwinter Clinic, Atlanta, Ga., March 14-15.

District of Columbia Dental Society, second and fourth Tuesdays in each month from October to June at the United States Public Health Service Auditorium, Washington.

Greater Philadelphia Annual Meeting, Philadelphia, February 2-4.

Dallas Midwinter Dental Clinic, Dallas, Texas, January 17-19.

North St. Louis District Dental Society, Annual Midwinter Meeting, January 26-27.

Rocky Mountain Midwinter Meeting, Denver, Colo., January 9-12.

Harvard Society of Orthodontists, Boston, Mass., January 12.

Seventh Cruise-Congress of the Pan American Medical Association: Section of Dentistry and Oral Surgery, January 15-31.

American Dental Society of Europe, Stockholm, August 1-3.

Eastern Association of Graduates of the Angle School of Orthodontia, Boston, Mass., January 24-25.

University of Buffalo School of Dentistry Alumni Association, Buffalo, N. Y., February 23-25.

International College of Dentists, U. S. Section, Chicago, Ill., February 13.

STATE SOCIETIES

January

Delaware, at Wilmington

Rhode Island, at Providence (12-13)

February

Minnesota, at St. Paul (22-24)

April

Alabama, at Birmingham (11-13)
Arizona, at Tucson (23-24)
California, at Stockton (4-6)
Kansas, at Wichita (24-27)
Kentucky, at Louisville (4-6)
Louisiana, at Alexandria (28-30)
Massachusetts, at Boston (25-28)
Michigan, at Detroit (25-27)
Mississippi, at Meridian (25-26)
New Jersey, at Atlantic City (20-22)
Oklahoma, at Tulsa (17-20)
Texas, at San Antonio (25-28)
Virginia, at Richmond (4-6)
Wisconsin, at Milwaukee (25-28)

May

Arkansas, at Little Rock (16-18)
Connecticut, at New Haven (4-6)
Georgia, at Macon (16-18)
Illinois, at Peoria (10-12)
Indiana, at Indianapolis (16-18)
Iowa, at Davenport (3-5)
Maryland, at Baltimore (2-3)
Missouri, at Columbia (8-9)
Montana, at Helena (5-7)
Nebraska, at Lincoln (16)
New York, at Syracuse (10-13)
North Carolina, at Winston-Salem (2-4)
North Dakota, at Minot (16-18)
Pennsylvania, at Philadelphia (3-5)
South Dakota, at Watertown (23-24)
Tennessee, at Chattanooga (9-12)
Vermont, at Burlington (18-19)
West Virginia, at Wheeling (16-18)

June

Colorado, at Estes Park (20-22)
Maine, at Portland (27-28)
Nevada, at Reno (4)
New Hampshire, at North Conway (6-7)
New Mexico, at Carlsbad

November

Ohio, at Cleveland

STATE BOARDS OF DENTAL EXAMINERS

Kentucky, June 14-17. Robert L. Sprau, 970 Baxter Ave., Louisville, Secretary.

New Jersey, June 27-July 2. Walter A. Wilson, 148 W. State St., Trenton, Secretary.

KENTUCKY STATE DENTAL ASSOCIATION

The sixty-ninth annual meeting of the Kentucky State Dental Association will be held at the Brown Hotel, Louisville, April 4-6.

J. H. Fullenwider, *Secretary,*
1101 Heyburn Bldg.,
Louisville.

ILLINOIS STATE DENTAL SOCIETY

The seventy-fourth annual meeting of the Illinois State Dental Society will be held in Peoria, May 10-12.

C. N. Newlin, *Secretary,*
627 Jefferson Bldg.,
Peoria.

MAINE DENTAL SOCIETY

The seventy-third anniversary meeting of the Maine Dental Society will be held at the Eastland Hotel, Portland, June 27-28.

George A. Philips, *Secretary,*
31 Central St.,
Bangor.

MONTANA STATE DENTAL ASSOCIATION

The thirty-fifth annual meeting of the Montana State Dental Association will be held in Helena, May 5-7.

T. T. Rider, *Secretary,*
9 Higgins Block,
Missoula.

KENTUCKY STATE BOARD OF DENTAL EXAMINERS

The next examination of the Kentucky State Board of Dental Examiners will be held June 14-17. Address all communications to

Robert L. Sprau, *Secretary,*
970 Baxter Ave.,
Louisville.

STATE BOARD OF REGISTRATION AND EXAMINATION IN DENTISTRY OF NEW JERSEY

The State Board of Registration and Examination in Dentistry of New Jersey will hold its annual examination commencing June 27 and continuing five days thereafter. On application to the secretary, a copy of the requirements and rules, instruction sheet and preliminary application blank will be sent. Preliminary application blank, together with examination fee of $25, must be filed on or before March 15 for the succeeding June examinations or before September 1 for the succeeding December examinations.

Walter A. Wilson, *Secretary,*
148 W. State St.,
Trenton.

ACADEMY OF ANESTHESIOLOGY IN ORAL SURGERY

The Academy of Anesthesiology in Oral Surgery Inc. (New York Chapter) will hold its regular monthly meeting January 19 at the George Washington Hotel, New York City. Those desiring to attend, communicate with

J. M. Eskow, *Secretary,*
147 Market St.,
Perth Amboy, N. J.

EASTERN ASSOCIATION OF GRADUATES OF THE ANGLE SCHOOL OF ORTHODONTIA

The annual meeting of the Eastern Association of Graduates of the Angle School of Orthodontia will be held at the Boston Medical Library, Boston, Mass., January 24-25.

E. Stanley Butler, *Secretary,*
55 Locust Ave.
New Rochelle, N. Y.

FIVE STATE POST GRADUATE CLINIC

The District of Columbia Dental Society will be host to the Five State Post Graduate Clinic March 6-9 at the Mayflower Hotel, Washington, D. C. The program committee of the District of Columbia Dental Society has arranged a clinic based on the slogan "Dental Health for American Youth," suggested by C. Willard Camalier, President of the American Dental Association, for the 1938 session of the national association. Among the essayists will be Lon W. Morrey, director of the Bureau of Public Relations of the American Dental Association; Malcolm W. Carr, New York City, oral surgeon at New York Polyclinic Hospital and Medical School; Oscar V. Batson, professor of anatomy, Graduate School of Medicine, University of Pennsylvania, Philadelphia, Pa.; Albert J. Irving, New York City; Rudolf

Kronfeld, professor of histology, Chicago College of Dental Surgery, Chicago, Ill., and Alexander H. Paterson, professor of prosthetic dentistry, University of Maryland. March 9, the entire day will be devoted to table clinics. March 7, a reception will be held in honor of the President of the American Dental Association, Dr. Camalier, of Washington.

JOSEPH F. MANLEY, *Chairman,*
Publicity Committee,
1726 Eye St., N.W.,
Washington, D. C.

CHICAGO DENTAL SOCIETY

The annual Midwinter Meeting of the Chicago Dental Society will be held February 14-18, at the Stevens Hotel in Chicago. An important change in program will be a feature of this year's meeting. One full day has been added to allow members and visitors to examine the host of exhibits and attend the numerous lectures that are being arranged. Other changes have also been made in the program to make this meeting more attractive and valuable.

As usual, the Midwinter Meeting of the Chicago Dental Society will provide an opportunity for dentists to partake of a valuable scientific program covering every phase of dentistry. The addition of one day allows for more clinics, which are to be given by practitioners from Chicago as well as from almost every other part of the United States. Numerous changes have also been made in the social program.

UNITED STATES PATENTS APPLICABLE OR PERTAINING TO DENTISTRY ISSUED DURING NOVEMBER 1937

November 2

No. 2,097,687, to DAVID CURTIS. Surface Anesthetic.

No. 2,097,701, to HENRY P. PFEIFFER. Machine for Conditioning False Teeth.

No. 2,097,987, to CHARLES EDWARD PHILLIPS. Toothbrush.

November 9

No. 2,098,317, to MARTIN STAUNT. Dental Appliance.

No. 2,098,340, to JOSEPH P. HENAHAN. Oral Airway Dam.

No. 2,098,524, to ARTHUR E. SMITH. Syringe.

No. 2,098,584, to BENJAMIN A. LINCOLN. Interchangeable Teeth.

No. 2,098,732, to THOMAS F. PRATHER. Dental Apparatus.

No. 2,098,879, to ALAN RICHARD POWELL. Alloy for Dental Plates.

No. 2,098,932, to JACOB A. SAFFIR. Dental Cuspidor.

Des. 106,880, to DAYTON BUMGARDNER and ALEXANDER B. PICKANDS. Design for a Dental Flask Attachment.

November 16

No. 2,099,087, to ALVA JAMES VANCE. Apparatus for Effecting Separation of the Parts of Dentures.

No. 2,099,317, to VICTOR E. SCHMIEDEKNECHT. Dental Lavatory.

No. 2,099,336, to FRED E. HART. Combined Toothbrush Holder and Sterilizer.

No. 2,099,454, to IVAR E. SIQVELAND. Dental Matrix.

November 23

No. 2,099,688, to WARREN E. HILL and CLIFFORD L. MCARTHUR. Toothbrush and Process for Making Same.

No. 2,099,841, to KARL CONNELL. Apparatus for the Administration of Gases.

No. 2,099,842, to KARL CONNELL. Gas Flow Means for Anesthetic Apparatus and the Like.

No. 2,099,843, to KARL CONNELL. Method and Means for the Formation of Breathing Tubes and the Like.

No. 2,100,116, to GEORGE FARRELL WEBB. Method and Apparatus for Treating Pyorrhea.

No. 2,100,272, to GUY R. SAWYER. Electric Reversible Toothbrush.

November 30

No. 2,100,319, to HAROLD J. BROWN and GEORGE E. FARRELL. Dental or Surgical Instruments.

No. 2,100,344, to GUSTAV H. MEDART. Buffing Hood.

No. 2,100,778, to JAY A. HEIDBRINK. Gas Administering Machine.

No. 2,100,960, to HERBERT JACOBY. Combination Dentifrice Dispenser and Toothbrush Holder.

Des. 107,228, to LOUIS GOODMAN. Design for a Toothbrush.

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